PROCEEDINGS

OF

The American Association

FOR THE

ADVANCEMENT OF SCIENCE,

FIFTY-THIRD MEETING

HELD AT

ST. LOUIS, MO.

DECEMBER, 1903–JANUARY, 1904.

PUBLISHED BY THE PERMANENT SECRETARY

1904

EDITED BY

L. O. HOWARD,

Permanent Secretary

PRESS OF GIBSON BROS.
WASHINGTON, D. C.
1904

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Officers of the St. Louis Meeting.

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[1] All Committees are expected to present their reports to the COUNCIL not later than the third day of the meeting. Committees sending their reports to the Permanent Secretary one month before a meeting can have them printed for use at the meeting.

11. *Committee on the Teaching of Anthropology in America.*

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12. *Committee on the Relations of the Journal "Science" with the Association.*

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13. *Committee on the Relations of Plants and Climate.*

William Trelease, *Chairman*, D. T. MacDougal, J. M. Coulter.

14. *Committee on the Atomic Weight of Thorium.*

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15. *Committee on the Velocity of Light.*

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Meetings and Officers of the Association of American Geologists and Naturalists.

Meeting.	Date.	Place.	Chairman.	Secretary.	Assistant Secretary.	Treasurer.
1st	April 2, 1840,	Philadelphia,	Edw. Hitchcock,*	L. C. Beck,*		
2d	April 5, 1841,	Philadelphia,	Benj. Silliman,*	L. C. Beck,*	B. Silliman, Jr.,* C. B. Trego,*	
3d	April 25, 1842,	Boston,	S. G. Morton,*	C. T. Jackson,*	J. D. Whitney,* M. B. Williams,*	
4th	April 26, 1843.	Albany,	Henry D. Rogers,*	B. Silliman, Jr.,*		John Locke.*
5th	May 8, 1844,	Washington,	John Locke,*	B. Silliman, Jr.,* O. P. Hubbard,		Douglas Houghton.*
6th	April 30, 1845,	New Haven,	Wm. B. Rogers,*	B. Silliman, Jr.,* J. Law. Smith,*		Douglas Houghton.*
7th	Sept. 2, 1846,	New York,	C. T. Jackson,*	B. Silliman, Jr.,*		E. C. Herrick.*
8th	Sept. 20, 1847,	Boston,	Wm. B. Rogers,*†	Jeffries Wyman,*		B. Silliman, Jr.*

* Deceased.

† Professor Rogers, as chairman of this last meeting, called the first meeting of the new Association to order and presided until it was fully organized by the adoption of a constitution. As he was thus the first presiding officer of the new Association, it was directed at the Hartford meeting that his name be placed at the head of the Past Presidents of the American Association for the Advancement of Science.

Meetings	Place	Date	Members in attendance	Number of members
1	Philadelphia	Sept. 20, 1848	?	461
2	Cambridge	Aug. 14, 1849	?	540
3	Charleston	Mar. 12, 1850	?	622
4	New Haven	Aug. 19, 1850	?	704
5	Cincinnati	May 5, 1851	87	800
6	Albany	Aug. 19, 1851	194	769
7	Cleveland	July 28, 1853	?	940
8	Washington	April 26, 1854	168	1004
9	Providence	Aug. 15, 1855	166	605
10	2d Albany	Aug. 20, 1856	381	722
11	Montreal	Aug. 12, 1857	351	946
12	Baltimore	April 28, 1858	190	962
13	Springfield	Aug. 3, 1859	190	862
14	Newport	Aug. 1, 1860	135	644
15	Buffalo	Aug. 15, 1866	79	637
16	Burlington	Aug. 21, 1867	73	415
17	Chicago	Aug. 5, 1868	259	686
18	Salem	Aug. 18, 1869	244	511
19	Troy	Aug. 17, 1870	188	536
20	Indianapolis	Aug. 16, 1871	196	668
21	Dubuque	Aug. 15, 1872	164	610
22	Portland	Aug. 20, 1873	195	670
23	Hartford	Aug. 12, 1874	224	722
24	Detroit	Aug. 11, 1875	165	807
25	2d Buffalo	Aug. 23, 1876	215	867
26	Nashville	Aug. 29, 1877	173	953
27	St. Louis	Aug. 21, 1878	134	962
28	Saratoga	Aug. 27, 1879	256	1030
29	Boston	Aug. 25, 1880	997	1555
30	2d Cincinnati	Aug. 17, 1881	500	1699
31	2d Montreal	Aug. 23, 1882	937	1922
32	Minneapolis	Aug. 15, 1883	328	2033
33	2d Philadelphia	Sept. 3, 1884	1261*	1981
34	Ann Arbor	Aug. 26, 1885	364	1956
35	3d Buffalo	Aug. 18, 1886	445	1886
36	New York	Aug. 10, 1887	729	1956
37	2d Cleveland	Aug. 14, 1888	342	1964
38	Toronto	Aug. 26, 1889	424	1952
39	2d Indianapolis	Aug. 19, 1890	364	1944
40	2d Washington	Aug. 19, 1891	653†	2054
41	Rochester	Aug. 17, 1892	456	2037
42	Madison	Aug. 17, 1893	290	1939
43	Brooklyn	Aug. 15, 1894	488	18[illegible]
44	2d Springfield	Aug. 28, 1895	368	1913
45	4th Buffalo	Aug. 24, 1896	333	189[illegible]
46	2d Detroit	Aug. 9, 1897	283‡	1782
47	2d Boston	Aug. 22, 1898	903	1729
48	Columbus	Aug. 21, 1899	353	1721
49	2d New York	June 25, 1900	434	1925
50	Denver	Aug. 24, 1901	311	2703
51	Pittsburg	June 28 to July 3, 1902.	435	3473
52	3d Washington	Dec. 27, 1902, to Jan. 2, 1903.	975	3596
53	2d St. Louis.	Dec. 28, 1903, to Jan. [illegible], 1904.	335	4[illegible]75

* Including 303 Members of the British Association and 9 other foreign guests.
† Including 24 Foreign Honorary Members for the meeting.
‡ Including 15 Foreign Honorary Members and Associates for the meeting.

Officers of the Meetings of the Association.

[The number before the name is that of the meeting; the year of the meeting follows the name; the asterisk after a name indicates that the member is deceased.]

PRESIDENTS.

1. Wm. B. Rogers,* 1848.
   W. C. Redfield,* 1848.
2. Joseph Henry,* 1849.
3. A. D. Bache,* March meeting, 1850, in the ab-
4. sence of Joseph Henry.* August meeting, 1850.
5. May meeting, 1851.
6. Louis Agassiz,* August meeting, 1851.
   (No meeting in 1852.)
7. Benjamin Pierce,* 1853.
8. James D. Dana,* 1854.
9. John Torrey,* 1855.
10. James Hall,* 1856.
11. Alexis Caswell,* 1857, in place of J. W. Bailey,* deceased. 1858, in the ab-
12. sence of Jeffries Wyman.*
13. Stephen Alexander,* 1859.
14. Isaac Lea,* 1860.
    (No meetings for 1861–65.)
15. F. A. P. Barnard,* 1866.
16. J. S. Newberry,* 1867.
17. B. A. Gould,* 1868.
18. J. W. Foster,* 1869.
19. T. Sterry Hunt,* 1870, in the absence of Wm. Chauvenet.*
20. Asa Gray,* 1871.
21. J. Lawrence Smith,* 1872.
22. Joseph Lovering,* 1873.
23. J. L. LeConte,* 1874.
24. J. E. Hilgard,* 1875.
25. William B. Rogers,* 1876.
26. Simon Newcomb, 1877.
27. O. C. Marsh,* 1878.
28. G. F. Barker, 1879.
29. Lewis H. Morgan,* 1880.
30. G. J. Brush, 1881.
31. J. W. Dawson, 1882.
32. C. A. Young, 1883.
33. J. P. Lesley,* 1884.
34. H. A. Newton,* 1885.
35. Edward S. Morse, 1886.
36. S. P. Langley, 1887.
37. J. W. Powell,* 1888.
38. T. C. Mendenhall, 1889.
39. G. Lincoln Goodale, 1890.
40. Albert B. Prescott, 1891.
41. Joseph LeConte,* 1892.
42. William Harkness,* 1893.
43. Daniel G. Brinton,* 1894.
44. E. W. Morley, 1895.
45. Edward D. Cope,* 1896. Theodore Gill, as senior vice-president acted after the death of Prof. Cope.
46. Wolcott Gibbs, 1897, absent. W J McGee, Acting President.
47. F. W. Putnam, 1898.
48. Edward Orton,* 1899. Grove K. Gilbert, elected by the General Committee December, 1899, to fill the vacancy caused by the death of Prof. Orton.
49. R. S. Woodward, 1900.
50. C. S. Minot, 1901.
51. Asaph Hall, 1902.
52. Ira Remsen, 1903.
53. Carroll D. Wright. 1904.
54. W. G. Farlow, 1905.

VICE-PRESIDENTS.

There were no Vice-Presidents until the 11th meeting when there was a single Vice-President for each meeting. At the 24th meeting, the Association met in Sections A and B, each presided over by a Vice-President. At the 31st meeting nine sections were organized, each with a Vice-President as its presiding officer. In 1886 Section G (Microscopy) was given up. In 1892, Section F was divided into F, Zoology; G, Botany.

1857–1874.

11. ALEXIS CASWELL,* 1857, acted as President.
12. JOHN E. HOLBROOK,* 1858, not present.
13. EDWARD HITCHCOCK,* 1859.
14. B. A. GOULD,* 1860.
15. B. A. GOULD,* 1866, in the absence of R. W. GIBBES.
16. WOLCOTT GIBBS, 1867.
17. CHAS. WHITTLESEY,* 1868.
18. OGDEN N. ROOD, 1869.
19. T. STERRY HUNT,* 1870, acted as President.
20. G. F. BARKER, 1871.
21. ALEX. WINCHELL,* 1872.
22. A. H. WORTHEN,* 1873. not present.
23. C. S. LYMAN,* 1874.

1875–1881.

Section A.—Mathematics, Physics, and Chemistry.

24. H. A. NEWTON,* 1875.
25. C. A. YOUNG, 1876.
26. R. H. THURSTON, 1877, in the absence of E. C. PICKERING.
27. R. H. THURSTON,* 1878.
28. S. P. LANGLEY, 1879.
29. ASAPH HALL, 1880.
30. WM. HARKNESS,* 1881, in the absence of A. M. MAYER.*

Section B.—Natural History.

24. J. W. DAWSON, 1875.
25. EDWARD S. MORSE, 1876.
26. O. C. MARSH,* 1877.
27. AUG. R. GROTE, 1878.
28. J. W. POWELL,* 1879.
29. ALEX. AGASSIZ, 1880.
30. EDWARD T. COX, 1881, in the absence of GEORGE ENGELMANN.*

CHAIRMEN OF SUBSECTIONS, 1875–1881.

Subsection of Chemistry.

24. S. W. JOHNSON, 1875.
25. G. F. BARKER, 1876.
26. N. T. LUPTON,* 1877.
27. F. W. CLARKE, 1878.
28. F. W. CLARKE, 1879, in the absence of IRA REMSEN.
29. J. M. ORDWAY, 1880.
30. G. C. CALDWELL, 1881, in the absence of W. R. NICHOLS.*

Subsection of Microscopy.

25. R. H. WARD, 1876.
26. R. H. WARD, 1877.
27. R. H. WARD, 1878, in the absence of G. S. BLACKIE.*
28. E. W. MORLEY, 1879.
29. S. A. LATTIMORE, 1880.
30. A. B. HERVEY, 1881.

Subsection of Anthropology.

24. LEWIS H. MORGAN,* 1875.
25. LEWIS H. MORGAN,* 1876.
26. DANIEL WILSON,* 1877, not present.
27. United with Section B.
28. DANIEL WILSON,* 1879.
29. J. W. POWELL,* 1880.
30. GARRICK MALLERY,* 1881.

Subsection of Entomology.

30. J. G. MORRIS,* 1881.

VICE-PRESIDENTS OF SECTIONS, 1882–

Section A.—Mathematics and Astronomy.

31. W. A. ROGERS,* 1882, in the absence of WM. HARKNESS.*
32. W. A. ROGERS,* 1883.
33. H. T. EDDY, 1884.
34. WM. HARKNESS,* 1885, in the absence of J. M. VAN VLECK.
35. J. W. GIBBS,* 1886.
36. J. R. EASTMAN, 1887, in place of W. FERREL,* res'd.
37. ORMOND STONE, 1888.
38. R. S. WOODWARD, 1889.
39. S. C. CHANDLER, 1890.
40. E. W. HYDE, 1891.
41. J. R. EASTMAN, 1892.
42. C. L. DOOLITTLE, 1893.
43. { G. C. COMSTOCK, 1894. EDGAR FRISBY, 1894. }
44. EDGAR FRISBY, 1895, in place of E. H. HOLDEN, resigned.
45. ALEX. MACFARLANE, 1896, in place of WM. E. STORY, resigned.
46. W. W. BEMAN, 1897.
47. E. E. BARNARD, 1898.
48. ALEX. MACFARLANE, 1899.
49. ASAPH HALL, JR., 1900.
50. JAMES MACMAHON, 1901.
51. G. W. HOUGH, 1902.
52. GEORGE BRUCE HALSTED, 1903.
53. O. H. TITTMANN, 1904.
54. ALEXANDER ZIWET, 1905.

Section B.—Physics.

31. T. C. MENDENHALL, 1882.
32. H. A. ROWLAND,* 1883.
33. J. TROWBRIDGE, 1884.
34. S. P. LANGLEY, 1885, in place of C. F. BRACKETT, res'd.
35. C. F. BRACKETT, 1886.
36. W. A. ANTHONY, 1887.
37. A. A. MICHELSON, 1888.
38. H. S. CARHART, 1889.
39. CLEVELAND ABBE, 1890.
40. F. E. NIPHER, 1891.
41. B. F. THOMAS, 1892.
42. E. L. NICHOLS, 1893.
43. WM. A. ROGERS, 1894.
44. W. LECONTE STEVENS, 1895.
45. CARL LEO MEES, 1896.
46. CARL BARUS, 1897.
47. F. P. WHITMAN, 1898.
48. ELIHU THOMSON, 1899.
49. ERNEST MERRITT, 1900.
50. D. B. BRACE, 1901.
51. W. S. FRANKLIN, 1902.
52. ERNEST F. NICHOLS, 1903.
53. E. H. HALL, 1904.
54. WM. F. MAGIE, 1905.

Section C.—Chemistry.

31. H. C. BOLTON,* 1882.
32. E. W. MORLEY, 1883.
33. J. W. LANGLEY, 1884.
34. N. T. LUPTON,* 1885, in the absence of W. R. NICHOLS.
35. H. W. WILEY, 1886.
36. A. B. PRESCOTT, 1887.
37. C. E. MUNROE, 1888.
38. W. L. DUDLEY, 1889.
39. R. B. WARDER, 1890.
40. R. C. KEDZIE, 1891.
41. ALFRED SPRINGER, 1892.
42. EDWARD HART, 1893.
43. T. H. NORTON, 1894.
44. WM. MCMURTRIE, 1895.
45. W. A. NOYES, 1896.
46. W. P. MASON, 1897.
47. EDGAR F. SMITH, 1898.
48. F. P. VENABLE, 1899.
49. JAS. LEWIS HOWE, 1900.
50. JOHN H. LONG, 1901.
51. H. A. WEBER, 1902.
52. CHARLES BASKERVILLE, 1903.
53. W. D. BANCROFT, 1904.
54. L. P. KINNICUTT, 1905.

VICE-PRESIDENTS OF SECTIONS, CONTINUED.

Section D.—Mechanical Science and Engineering.

31. W. P. TROWBRIDGE,* 1882.
32. DEVOLSON WOOD, 1883, absent, but place was not filled.
33. R. H. THURSTON,* 1884.
34. J. BURKITT WEBB, 1885.
35. O. CHANUTE, 1886.
36. E. B. COXE, 1887.
37. C. J. H. WOODBURY, 1888.
38. JAMES E. DENTON, 1889.
39. JAMES E. DENTON, 1890, in place of A. BEARDSLEY, absent.
40. THOMAS GRAY, 1891.
41. J. B. JOHNSON, 1892.
42. S. W. ROBINSON, 1893.
43. MANSFIELD MERRIMAN, 1894.
44. WILLIAM KENT, 1895.
45. FRANK O. MARVIN, 1896.
46. JOHN GALBRAITH, 1897.
47. JOHN GALBRAITH, 1898, in the absence of M.E.COOLEY.
48. STORM BULL, 1899.
49. JOHN A. BRASHEAR, 1900.
50. H. S. JACOBY, 1901.
51. J. J. FLATHER, 1902.
52. CLARENCE A. WALDO, 1903.
53. C. M. WOODWARD, 1904.
54. D. S. JACOBUS, 1905.

Section E.—Geology and Geography.

31. E. T. COX, 1882.
32. C. H. HITCHCOCK, 1883.
33. N. H. WINCHELL, 1884.
34. EDWARD ORTON,* 1885.
35. T. C. CHAMBERLIN, 1886.
36. G. K. GILBERT, 1887.
37. GEORGE H. COOK,* 1888.
38. CHARLES A. WHITE, 1889.
39. JOHN C. BRANNER, 1890.
40. J. J. STEVENSON, 1891.
41. H. S. WILLIAMS, 1892.
42. CHARLES D. WALCOTT, 1893.
43. SAMUEL CALVIN, 1894.
44. JED. HOTCHKISS, 1895.
45. B. K. EMERSON, 1896.
46. { I. C. WHITE, 1897. / E. W. CLAYPOLE,* 1897. }
47. H. L. FAIRCHILD, 1898.
48. J. F. WHITEAVES, 1899.
49. J. F. KEMP, 1900.
50. C. R. VAN HISE, 1901.
51. JOSEPH A. HOLMES, 1902, in the absence of O. A. DERBY.
52. WM. M. DAVIS, 1903.
53. I. C. RUSSELL, 1904.
54. EUGENE A. SMITH, 1905.

Section F.—Biology, 1882–1892.

31. W. H. DALL, 1882.
32. W. J. BEAL, 1883.
33. E. D. COPE,* 1884.
34. T. J. BURRILL, 1885, in the absence of B. G. WILDER.
35. H. P. BOWDITCH, 1886.
36. W. G. FARLOW, 1887.
37. C. V. RILEY,* 1888.
38. GEORGE L. GOODALE, 1889.
39. C. S. MINOT, 1890.
40. J. M. COULTER, 1891.
41. S. H. GAGE, 1892.

Section F.—Zoology.

42. HENRY F. OSBORN, 1893.
43. J. A. LINTNER,* 1894, in place of S. H. SCUDDER, res'd.
44. L. O. HOWARD, 1895, in place of D. S. JORDAN, res'd.
45. THEO. GILL, 1896.
46. L. O. HOWARD, 1897, in place of G. BROWN GOODE,* deceased.
47. A. S. PACKARD, 1898.
48. S. H. GAGE, 1899.
49. C. B. DAVENPORT, 1900.
50. D. S. JORDAN, 1901.
51. E. L. MARK, 1902, in the absence of C. C. NUTTING.

VICE-PRESIDENTS OF SECTIONS, CONTINUED.

52. C. W. HARGITT, 1903.
53. E. L. MARK, 1904.
54. C. HART MERRIAM, 1905.

Section G. Microscopy, 1882–85.

31. A. H. TUTTLE, 1882.
32. J. D. COX, 1883.
33. T. G. WORMLEY,* 1884.
34. S. H. GAGE, 1885.

(Section united with F in 1886)

Section G.—Botany.

42. CHARLES E. BESSEY, 1893.
43. { L. M. UNDERWOOD, 1894. C. E. BESSEY, 1894.
44. J. C. ARTHUR, 1895.
45. N. L. BRITTON, 1896.
46. G. F. ATKINSON, 1897.
47. W. G. FARLOW, 1898.
48. C. R. BARNES, 1899.
49. W. TRELEASE, 1900.
50. B. T. GALLOWAY, 1901.
51. C. E. BESSEY, 1902, in the absence of D. H. CAMPBELL.
52. F. V. COVILLE, 1903.
53. T. H. MACBRIDE, 1904.
54. B. L. ROBINSON, 1905.

Section H.—Anthropology.

31. ALEX. WINCHELL,* 1882.
32. OTIS T. MASON, 1883.
33. EDWARD S. MORSE, 1884.
34. J. OWEN DORSEY,* 1885, in the absence of W. H. DALL.
35. HORATIO HALE,* 1886.
36. D. G. BRINTON,* 1887.
37. CHARLES C. ABBOTT, 1888.
38. GARRICK MALLERY,* 1889.
39. FRANK BAKER, 1890.
40. JOSEPH JASTROW, 1891.
41. W. H. HOLMES, 1892.
42. J. OWEN DORSEY,* 1893.
43. FRANZ BOAS, 1894.
44. F. H. CUSHING,* 1895.
45. ALICE C. FLETCHER, 1896.
46. W J MCGEE, 1897.
47. J. MCK. CATTELL, 1898.
48. THOMAS WILSON,* 1899.
49. A. W. BUTLER, 1900.
50. J. WALTER FEWKES, 1901.
51. STEWART CULIN, 1902.
52. GEO. A. DORSEY, 1903.
53. M. H. SAVILLE, 1904.
54. WALTER HOUGH, 1905.

Section I.—Social and Economic Science.

31. E. B. ELLIOTT,* 1882.
32. FRANKLIN B. HOUGH,* 1883.
33. JOHN EATON,* 1884.
34. EDWARD ATKINSON, 1885.
35. JOSEPH CUMMINGS,* 1886.
36. H. E. ALVORD, 1887.
37. CHARLES W. SMILEY, 1888.
38. CHARLES S. HILL, 1889.
39. J. RICHARDS DODGE, 1890.
40. EDMUND J. JAMES, 1891.
41. L. F. WARD, 1892, in place of S. D. HORTON,* resigned.
42. WILLIAM H. BREWER, 1893.
43. HENRY FARQUHAR, 1894.
44. B. E. FERNOW, 1895.
45. W. L. LAZENBY, 1896.
46. R. T. COLBURN, 1897.
47. ARCHIBALD BLUE, 1898.
48. MARCUS BENJAMIN, 1899.
49. MARCUS BENJAMIN, 1900, in the absence of C. M. WOODWARD.
50. JOHN HYDE, 1901.
51. JOHN HYDE, 1902, in the absence of CARROLL D. WRIGHT.
52. H. T. NEWCOMB, 1903.
53. SIMEON E. BALDWIN, 1904.
54. MARTIN A. KNAPP, 1905.

Section K.—Physiology and Experimental Medicine.

51. W. H. WELCH, 1902.
52. W. H. WELCH, 1903.
53. H. P. BOWDITCH, 1904.
54. H. P. BOWDITCH, 1905.

SECRETARIES.

General Secretaries, 1848–

1. WALTER R. JOHNSON,* 1848
2. E. N. HORSFORD,* 1849, in the absence of JEFFRIES WYMAN.*
3. L. R. GIBBS, 1850, in the absence of E. C. HERRICK.*
4. E. C. HERRICK,* 1850.
5. WM. B. ROGERS,* 1851, in the absence of E. C. HERRICK.*
6. WM. B. ROGERS,* 1851.
7. S. ST. JOHN,* 1853, in the absence of J. D. DANA.*
8. J. LAWRENCE SMITH,* 1854.
9. WOLCOTT GIBBS, 1855.
10. B. A. GOULD,* 1856.
11. JOHN L. LECONTE,* 1857.
12. W.M.GILLESPIE,*1858,in the absence of WM.CHAUVENET.*
13. WM. CHAUVENET,* 1859.
14. JOSEPH LECONTE,* 1860.
15. ELIAS LOOMIS,* 1866, in the absence of W. P. TROWBRIDGE.*
16. C. S. LYMAN,* 1867.
17. SIMON NEWCOMB, 1868, in the absence of A.P.ROCKWELL.
18. O. C. MARSH,* 1869.
19. F. W. PUTNAM, 1870, in the absence of C. F. HARTT.*
20. F. W. PUTNAM, 1871.
21. EDWARD S. MORSE, 1872.
22. C. A. WHITE, 1873.
23. A. C. HAMLIN, 1874.
24. S. H. SCUDDER, 1875.
25. T. C. MENDENHALL, 1876.
26. AUG. R. GROTE, 1877.
27. H. C. BOLTON,* 1878.
28. H. C. BOLTON,* 1879, in the absence of GEORGE LITTLE.
29. J. K. REES, 1880.
30. C. V. RILEY,* 1881.
31. WILLIAM SAUNDERS, 1882.
32. J. R. EASTMAN, 1883.
33. ALFRED SPRINGER, 1884.
34. C. S. MINOT, 1885.
35. S. G. WILLIAMS,* 1886.
36. WILLIAM H. PETTEE, 1887.
37. JULIUS POHLMAN, 1888.
38. C. LEO MEES, 1889.
39. H. C. BOLTON,* 1890.
40. H. W. WILEY, 1891.
41. A. W. BUTLER, 1892.
42. T. H. NORTON, 1893.
43. H. L. FAIRCHILD, 1894.
44. JAS. LEWIS HOWE, 1895.
45. CHARLES R. BARNES, 1896.
46. ASAPH HALL, JR., 1897.
47. J. MCMAHON, 1898, in place of D.S.KELLICOTT,*deceased.
48. F. BEDELL, 1899.
49. CHAS. BASKERVILLE, 1900.
50. JOHN M. COULTER, 1901, in the absence of WILLIAM HALLOCK.
51. D. T. MACDOUGAL, 1902.
52. HENRY B. WARD, 1903.
53. C. W. STILES, 1904.
54. CHARLES S. HOWE, 1905.

Permanent Secretaries, 1851–

5–7. SPENCER F. BAIRD,*1851–4

8–17. JOSEPH LOVERING,*1854–68.

18. F. W. PUTNAM, 1869, in the absence of J. LOVERING.*

19–21. JOSEPH LOVERING,* 1870–73.

22–46. F. W. PUTNAM, 1873–98.

47–54. L. O. HOWARD, 1898–05.

Assistant General Secretaries, 1882–1887.

31. J. R. EASTMAN, 1882.
32. ALFRED SPRINGER, 1883.
33. C. S. MINOT, 1884, in the absence of E. S. HOLDEN.
34. S. G. WILLIAMS,* 1885, in the absence of C. C. ABBOTT.

Secretaries, Continued.

35. W. H. Pettee, 1886.
36. J. C. Arthur, 1887.

Secretaries of the Council, 1888–

37. C. Leo Mees, 1888.
38. H. C. Bolton,* 1889.
39. H. W. Wiley, 1890.
40. A. W. Butler, 1891.
41. T. H. Norton, 1892.
42. H. Leroy Fairchild, 1893.
43. Jas. Lewis Howe, 1894.
44. Charles R. Barnes, 1895.
45. Asaph Hall, Jr., 1896.
46. D. S. Kellicott,* 1897.
47. Frederick Bedell, 1898.
48. Charles Baskerville, 1899.
49. William Hallock, 1900.
50. D. T. MacDougal, 1901.
51. H. B. Ward, 1902.
52. Ch. Wardell Stiles, 1903.
53. Chas. S. Howe, 1904.
54. C. A. Waldo, 1905.

Secretaries of Section A.—Mathematics, Physics and Chemistry, 1875–1881.

24. S. P. Langley, 1875. T. C. Mendenhall, 1875.
25. A. W. Wright, 1876.
26. H. C. Bolton,* 1877.
27. F. E. Nipher, 1878.
28. J. K. Rees, 1879.
29. H. B. Mason, 1880.
30. E. T. Tappan, 1881, in the absence of Jno. Trowbridge.

Secretaries of Section B.—Natural History, 1874–1881.

24. Edward S. Morse, 1875.
25. Albert H. Tuttle, 1876.
26. William H. Dall, 1877.
27. George Little, 1878.
28. Wm. H. Dall, 1879, in the absence of A. C. Wetherby.
29. Charles V. Riley,* 1880.
30. William Saunders, 1881.

Secretaries of Subsections, 1875–1881.

Subsection of Chemistry.

24. F. W. Clarke, 1875.
25. H. C. Bolton,* 1876.
26. P. Schweitzer, 1877.
27. A. P. S. Stuart, 1878.
28. W. R. Nichols,* 1879.
29. C. E. Munroe, 1880.
30. Alfred Springer, 1881, in the absence of R. B. Warder.

Subsection of Entomology.

30. B. P. Mann, 1881.

Subsection of Anthropology.

24. F. W. Putnam, 1875.
25. Otis T. Mason, 1876.
26, 27. United with Section B.
28, 29, 30. J. G. Henderson, 1879–81.

Subsection of Microscopy.

25. E. W. Morley, 1876.
26. T. O. Sommers, Jr., 1877.
27. G. J. Engelmann, 1878.
28, 29. A. B. Hervey, 1879–80.
30. W. H. Seaman, 1881, in the absence of S. P. Sharples.

Secretaries of the Sections, 1882–

Section A.—Mathematics and Astronomy.

31. H. T. Eddy, 1882.
32. G. W. Hough, 1883, in the absence of W. W. Johnson.
33. G. W. Hough, 1884.
34. E. W. Hyde, 1885.
35. S. C. Chandler, 1886.
36. H. M. Paul, 1887.
37. C. C. Doolittle, 1888.

Secretaries of the Sections, Continued.

38. G. C. Comstock, 1889.
39. W. W. Beman, 1890.
40. F. H. Bigelow, 1891.
41. Winslow Upton, 1892.
42. C. A. Waldo, 1893, in the absence of A. W. Phillips.
43. J. C. Kershner, 1894, in place of W. W. Beman, res'd.
44. Asaph Hall, Jr., 1895, in place of E. H. Moore, res'd.
45. Edwin B. Frost, 1896.
46. James McMahon, 1897.
47. Winslow Upton, 1898, in place of Alex. Ziwet, resigned.
48. John F. Hayford, 1899.
49. W. M. Strong, 1900.
50. G. A. Miller, 1901, in place of H. C. Lord, resigned.
51. E. S. Crawley, 1902.
52. C. S. Howe, 1903.
53–57. L. G. Weld, 1904–1908.

Section B.—Physics.

31. C. S. Hastings, 1882.
32. F. E. Nipher, 1883, in the absence of C. K. Wead.
33. N. D. C. Hodges, 1884.
34. B. F. Thomas, 1885, in place of A. A. Michelson, resigned.
35. H. S. Carhart, 1886.
36. C. Leo Mees, 1887.
37. Alex. Macfarlane, 1888.
38. E. L. Nichols, 1889.
39. E. M. Avery, 1890.
40. Alex. Macfarlane, 1891.
41. Brown Ayres, 1892.
42. W. LeConte Stevens, 1893.
43. B. W. Snow, 1894.
44. E. Merritt, 1895.
45. Frank P. Whitman, 1896.
46. Frederick Bedell, 1897.
47. W. S. Franklin, 1898, in place of E. B. Rosa, resigned.
48. William Hallock, 1899.
49. R. A. Fessenden, 1900.
50. John Zeleny, 1901, in place of J. O. Reed, resigned.
51. E. F. Nichols, 1902.
52. D. C. Miller, 1903.
53–57. D. C. Miller, 1904–1908.

Section C.—Chemistry.

31. Alfred Springer, 1882.
32. J. W. Langley, 1883.
    W. McMurtrie, 1883.
33. H. Carmichael, 1884, in the absence of R. B. Warder.
34. F. P. Dunnington, 1885.
35. W. McMurtrie, 1886.
36. C. F. Mabery, 1887.
37. W. L. Dudley, 1888.
38. Edward Hart, 1889.
39. W. A. Noyes, 1890.
40. T. H. Norton, 1891.
41. Jas. Lewis Howe, 1892.
42. H. N. Stokes, 1893, in the absence of J. U. Nef.
43. Morris Loeb, 1894, in place of S. M. Babcock, resigned.
44. W. P. Mason, 1895.
    W. O. Atwater, 1895.
45. Frank P. Venable, 1896.
46. P. C. Freer, 1897.
47. C. Baskerville, 1898.
48. H. A. Weber, 1899.
49. A. A. Noyes, 1900.
50. W. McPherson, 1901.
51. F. C. Phillips, 1902.
52. H. N. Stokes, 1903.
53–57. Chas. L. Parsons, 1904–1908.

Section D.—Mechanical Science and Engineering.

31. J. Burkitt Webb, 1882, in the absence of C. B. Dudley.
32. J. Burkitt Webb, 1883, *pro tempore.*
33. J. Burkitt Webb, 1884.
34. C. J. H. Woodbury, 1885.

SECRETARIES OF THE SECTIONS, CONTINUED.

35. WILLIAM KENT, 1886.
36. G. M. BOND, 1887.
37. ARTHUR BEARDSLEY, 1888.
38. W. B. WARNER, 1889.
39. THOMAS GRAY, 1890.
40. WILLIAM KENT, 1891.
41. O. H. LANDRETH, 1892.
42. D. S. JACOBUS, 1893.
43. JOHN H. KINEALY, 1894.
44. H. S. JACOBY, 1895.
45. JOHN GALBRAITH, 1896.
46. JOHN J. FLATHER, 1897.
47. JOHN J. FLATHER, 1898, in the absence of W. S. ALDRICH.
48. J. M. PORTER, 1899.
49. W. T. MAGRUDER, 1900.
50. C. W. COMSTOCK, 1901, in the absence of W. H. JAQUES.
51. C. A. WALDO, 1902.
52. ELWOOD MEAD, 1903, in the absence of ALBERT KINGSBURY.
53–57. W. T. MAGRUDER, 1904–1908.

Section E.—Geology and Geography.

31. H. S. WILLIAMS, 1882, in the absence of C. E. DUTTON.
32. A. A. JULIEN, 1883.
33. E. A. SMITH, 1884.
34. G. K. GILBERT, 1885, in the absence of H. C. LEWIS.*
35. E. W. CLAYPOLE,* 1886.
36. W. M. DAVIS, 1887, in the absence of T. B. COMSTOCK.
37. JOHN C. BRANNER, 1888.
38. JOHN C. BRANNER, 1889.
39. SAMUEL CALVIN, 1890.
40. W J MCGEE, 1891.
41. R. D. SALISBURY, 1892.
42. W. H. HOBBS,* 1893, in place of R. T. HILL, resigned.
43. JED. HOTCHKISS,* 1894, in place of W. M. DAVIS, res'd.
44. J. PERRIN SMITH, 1895.
45. W. N. RICE, 1896, in place of A. C. GILL, resigned.
46. C. H. SMITH, JR., 1897.
47. WARREN UPHAM, 1898.
48. ARTHUR HOLLICK, 1899.
49. J. A. HOLMES, 1900.
50. H. B. PATTON, 1901, in the absence of R. A. F. PENROSE.
51. F. P. GULLIVER, 1902.
52. E. O. HOVEY, 1903.
53. G. B. SHATTUCK, 1904.
54–57. EDMUND O. HOVEY, 1905–1908.

Section F.—Biology, 1882–1892.

31. WILLIAM OSLER, 1882, in the absence of C. S. MINOT.
32. S. A. FORBES, 1883.
33. C. E. BESSEY, 1884.
34. J. A. LINTNER,* 1885, in place of C. H. FERNALD, res'd.
35. J. C. ARTHUR, 1886.
36. J. H. COMSTOCK, 1887.
37. B. E. FERNOW, 1888.
38. A. W. BUTLER, 1889.
39. J. M. COULTER, 1890.
40. A. J. COOK, 1891.
41. D. B. HALSTEAD, 1892.

Section F.—Zoology.

42. L. O. HOWARD, 1893.
43. JOHN B. SMITH, 1894, in place of WM. LIBBY, JR., resigned.
44. C. W. HARGITT, 1895, in place of S. A. FORBES, res'd.
45. D. S. KELLICOTT,* 1896.
46. C. C. NUTTING, 1897.
47. R. T. JACKSON, 1898, in place of C. W. STILES, resigned.
48. C. L. MARLATT, 1899, in place of F. W. TRUE, resigned.
49. C. H. EIGENMANN, 1900.
50. H. B. WARD, 1901.
51. C. W. STILES, 1902.
52. C. J. HERRICK, 1903.
53–57. C. J. HERRICK, 1904–08.

SECRETARIES OF THE SECTIONS, CONTINUED.

Section G.—Microscopy, 1882–85.

31. ROBERT BROWN, JR., 1882.
32. CARL SEILER, 1883.
33. ROMYN HITCHCOCK, 1884.
34. W. H. WALMSLEY, 1885.

Section G.—Botany.

42. B. T. GALLOWAY, 1893, in the absence of F. V. COVILLE.
43. CHAS. R. BARNES, 1894.
44. B. T. GALLOWAY, 1895. M. B. WAITE, 1895.
45. GEORGE F. ATKINSON, 1896.
46. F. C. NEWCOMBE, 1897.
47. ERWIN F. SMITH, 1898.
48. W. A. KELLERMAN, 1899.
49. D. T. MACDOUGAL, 1900.
50. ERNST A. BESSEY, 1901, in the absence of A. S. HITCHCOCK.
51. H. VON SCHRENK, 1902.
52. C. J. CHAMBERLAIN, 1903.
53–57. F. E. LLOYD, 1904–1908.

Section H.—Anthropology.

31. OTIS T. MASON, 1882.
32. G. H. PERKINS, 1883.
33. G. H. PERKINS, 1884, in the absence of W. H. HOLMES.
34. ERMINNIE A. SMITH,* 1885.
35. A. W. BUTLER, 1886.
36. CHAS. C. ABBOTT, 1887, in the absence of F. W. LANGDON.
37. FRANK BAKER, 1888.
38. W. M. BEAUCHAMP, 1889.
39. JOSEPH JASTROW, 1890.
40. W. H. HOLMES, 1891.
41. W. M. BEAUCHAMP, 1892, in place of S. CULIN, resigned.
42. W. K. MOOREHEAD, 1893.
43. A. F. CHAMBERLIN, 1894.
44. STEWART CULIN and W. W. TOOKER, 1895, in place of ANITA N. MCGEE, res'd.
45. G. H. PERKINS, 1896, in place of J. G. BOURKE,* dec'd.
46. ANITA N. MCGEE, 1897, in place of HARLAN I. SMITH, res'd.
47. MARSHALL H. SAVILLE, 1898.
48. E. W. SCRIPTURE, 1899, in place of GEO. A. DORSEY, resigned.
49. FRANK RUSSELL,* 1900.
50. G. G. MACCURDY, 1901.
51. HARLAN I. SMITH, 1902.
52. R. B. DIXON, 1903.
53–57. GEO. H. PEPPER–04–08.

Section I.—Social and Economic Science.

31. FRANKLIN B. HOUGH,* 1882. J. RICHARDS DODGE, 1882.
32. JOSEPH CUMMINGS,* 1883.
33. CHARLES W. SMILEY, 1884.
34. CHAS. W. SMILEY, 1885, in the absence of J. W. CHICKERING.
35. H. E. ALVORD, 1886.
36. W. R. LAZENBY, 1887.
37. CHARLES S. HILL, 1888.
38. J. RICHARDS DODGE, 1889.
39. B. E. FERNOW, 1890.
40. B. E. FERNOW, 1891.
41. HENRY FARQUHAR, 1892, in place of L. F. WARD, made Vice-President.
42. NELLIE S. KEDZIE, 1893.
43. MANLEY MILES, 1894.
44. W. R. LAZENBY, 1895, in place of E. A. ROSS, resigned.
45. R. T. COLBURN, 1896.
46. ARCHIBALD BLUE, 1897.
47. MARCUS BENJAMIN, 1898.
48. CALVIN M. WOODWARD, 1899.
49. H. T. NEWCOMB, 1900.
50. R. A. PEARSON, 1901, in place of CORA A. BENNESON, res'd.
51. F. R. RUTTER, 1902, in place of Walter F. Willcox, resigned.
52. F. H. HITCHCOCK, 1903.
53–57. J. F. CROWELL, 1904–08.

SECRETARIES OF THE SECTIONS, CONTINUED.

Section K.—Physiology and Experimental Medicine.

51. F. S. LEE, 1902.
52. F. S. LEE, 1903.
53. F. S. LEE, 1904.
54. . . . . 1905.

TREASURERS.

1. JEFFRIES WYMAN,* 1848.
2. A. L. ELWYN,* 1849.
3. ST. J. RAVENEL,* 1850, in the absence of A. L. ELWYN.*
4. A. L. ELWYN,* 1850.
5. SPENCER F. BAIRD,* 1851, in the absence of A. L. ELWYN.*

6–7. A. L. ELWYN,* 1851–53.

8. J. L. LECONTE,* 1854, in the absence of A. L. ELWYN.*

9–19. A. L. ELWYN,* 1855–1870.

20–30. WM. S. VAUX,* 1871–1881.

32–42. WM. LILLY,* 1882–93.

43–49. R. S. WOODWARD, 1894–1900.

50–54. R. S. WOODWARD, 1901–1905.

Commonwealth of Massachusetts.

In the Year One Thousand Eight Hundred and Seventy-Four.

AN ACT

TO INCORPORATE THE "AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE."

Be it enacted by the Senate and House of Representatives, in General Court assembled, and by the authority of the same, as follows:

SECTION 1. Joseph Henry of Washington, Benjamin Pierce of Cambridge, James D. Dana of New Haven, James Hall of Albany, Alexis Caswell of Providence, Stephen Alexander of Princeton, Isaac Lea of Philadelphia, F. A. P. Barnard of New York, John S. Newberry of Cleveland, B. A. Gould of Cambridge, T. Sterry Hunt of Boston, Asa Gray of Cambridge, J. Lawrence Smith of Louisville, Joseph Lovering of Cambridge, and John LeConte of Philadelphia, their associates, the officers and members of the Association, known as the "American Association for the Advancement of Science," and their successors, are hereby made a corporation by the name of the "American Association for the Advancement of Science," for the purpose of receiving, purchasing, holding, and conveying real and personal property, which it now is, or hereafter may be, possessed of, with all the powers and privileges, and subject to the restrictions, duties and liabilities set forth in the general laws which now or hereafter may be in force and applicable to such corporations.

SECTION 2. Said corporation may have and hold by purchase, grant, gift, or otherwise, real estate not exceeding one hundred thousand dollars in value, and personal estate of the value of two hundred and fifty thousand dollars.

SECTION 3. Any two of the corporators above named are hereby authorized to call the first meeting of the said corporation in the month of August next ensuing, by notice thereof "by mail," to each member of the said Association.

SECTION 4. This act shall take effect upon its passage.

HOUSE OF REPRESENTATIVES, March 10, 1874.
Passed to be enacted,
JOHN E. SANFORD, *Speaker*.

IN SENATE, March 17, 1874.
Passed to be enacted,
GEO. B. LORING, *President*.

March 19, 1874.
Approved.
W. B. WASHBURN.

SECRETARY'S DEPARTMENT,
Boston, April 3, 1874.
A true copy, Attest:
DAVID PULSIFER,
Deputy Secretary of the Commonwealth.

CONSTITUTION

OF THE

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

Incorporated by Act of the General Court of the Commonwealth of Massachusetts.

OBJECTS.

ARTICLE 1. The objects of the Association are, by periodical and migratory meetings, to promote intercourse between those who are cultivating science in different parts of America, to give a stronger and more general impulse and more systematic direction to scientific research, and to procure for the labors of scientific men increased facilities and a wider usefulness.

MEMBERSHIP.

ART. 2. The Association shall consist of members, fellows, patrons, corresponding members and honorary fellows.

MEMBERS.

ART. 3. Any person may become a member of the Association upon recommendation in writing by two members or fellows, and election by the Council. Any incorporated scientific society or institution, or any public or incorporated library, may be enrolled as a member of the Association by vote of the Council by payment of the initiation fee; such society, institution, or library may be represented by either the President, Curator, Director, or Librarian presenting proper credentials at any meeting of the Association for which the assessment has been paid.

ASSOCIATES.

Associates for any single meeting shall be admitted on the payment of three dollars, such associates to have all the privileges of the meeting, except reading papers and voting.

Members of scientific societies whose meetings are contemporaneous with, or immediately subsequent to, that of the Associa-

tion, and which are recognized by vote of the Council as "Affiliated Societies," may become associate members for that meeting on the payment of three dollars. They shall be entitled to all the privileges of membership except voting or appointment to office, but their names shall not appear in the list of members printed in the annual report.

Foreign Associates.

Any member or fellow of any national scientific or educational institution, or of any society or academy of science, of any country not in America, who may be present at any meeting of the Association shall, on presenting the proper credentials, be enrolled without fee as a Foreign Associate, and shall be entitled to all the privileges of the meeting except voting on matters of business.

Fellows.

Art. 4. Fellows shall be elected by the Council from such of the members as are professionally engaged in science, or have, by their labors, aided in advancing science. The election of fellows shall be by ballot, and a majority vote of the members of the Council at a designated meeting of the Council.

Patrons.

Art. 5. Any person paying to the Association the sum of one thousand dollars shall be classed as a patron, and shall be entitled to all the privileges of a member and to all its publications.

Honorary Fellows and Corresponding Members.

Art. 6. Honorary fellows of the Association, not exceeding three for each Section, may be elected, the nominations to be made by the Council and approved by ballot in the respective sections before election by ballot in General Session. Honorary fellows shall be entitled to all the privileges of fellows, and shall be exempt from all fees and assessments, and entitled to all publications of the Association issued after the date of their election. Corresponding members shall consist of such scientists not residing in America as may be elected by the Council, and their number shall be limited to fifty. Corresponding members shall be entitled to

all the privileges of members and to the annual volumes of Proceedings published subsequent to their election.

SUSPENSIONS.

ART. 7. The name of any member or fellow two years in arrears for annual dues shall be erased from the list of the Association, provided, that two notices of indebtedness, at an interval of at least three months, shall have been given; and no such person shall be restored until he has paid his arrearages or has been re-elected. The Council shall have power to exclude from the Association any member or fellow, on satisfactory evidence that said member or fellow is an improper person to be connected with the Association, or has in the estimation of the Council made improper use of his membership or fellowship.

OFFICERS.

ART. 8. No member or fellow shall take part in the organization of, or hold office in, more than one section at any one meeting.

ART. 9. The officers of the Association shall be elected by ballot by the General Committee from the fellows, and shall consist of a President, a Vice-President from each section, a Permanent Secretary, a General Secretary, a Secretary of the Council, a Treasurer, and a Secretary of each Section; these, with the exception of the Permanent Secretary, the Treasurer, and the Secretaries of the Sections, shall be elected at each meeting for the following one, and, with the exception of the Treasurer and the Permanent Secretary, shall not be re-eligible for the next two meetings. The term of office of the Permanent Secretary, of the Treasurer, and of the Secretaries of the Sections, shall be five years.

PRESIDENT.

ART. 10. The President, or, in his absence, the senior Vice-President present, shall preside at all General Sessions of the Association and at all meetings of the Council. It shall also be the duty of the President to give an address at a General Session of the Association at the meeting following that over which he presided.

VICE-PRESIDENTS.

ART. 11. The Vice-Presidents shall be chairmen of their respective Sections, and of their Sectional Committees, and it

shall be part of their duty to give an address, each before his own Section, at such time as the Council shall determine at the meeting subsequent to that at which he presides. The Vice-Presidents may appoint temporary chairmen to preside over the sessions of their sections, but shall not delegate their other duties. The Vice-Presidents shall have seniority in order of their continuous membership in the Association.

GENERAL SECRETARY.

ART. 12. The General Secretary shall be the Secretary of all General Sessions of the Association, and shall keep a record of the business of these sessions. He shall receive the records from the Secretaries of the Sections, which, after examination, he shall transmit with his own records to the Permanent Secretary within two weeks after the adjournment of the meeting.

SECRETARY OF THE COUNCIL.

ART. 13. The Secretary of the Council shall keep the records of the Council. He shall give to the Secretary of each Section the titles of papers assigned to it by the Council. He shall receive proposals for membership and bring them before the Council.

PERMANENT SECRETARY.

ART. 14. The Permanent Secretary shall be the executive officer of the Association under the direction of the Council. He shall attend to all business not specially referred to committees nor otherwise constitutionally provided for. He shall keep an account of all business that he has transacted for the Association, and make annually a general report for publication in the annual volume of Proceedings. He shall attend to the printing and distribution of the annual volume of Proceedings, and all other printing ordered by the Association. He shall issue a circular of information to members and fellows at least three months before each meeting, and shall, in connection with the Local Committee, make all necessary arrangements for the meetings of the Association. He shall provide the Secretaries of the Association with such books and stationery as may be required for their records and business, and shall provide members and fellows with such blank forms as may be required for facilitating the business of the Association. He shall collect all assessments

and admission fees, and notify members and fellows of their election, and of any arrearages. He shall receive, and bring before the Council, the titles and abstracts of papers proposed to be read before the Association. He shall keep an account of all receipts and expenditures of the Association, and report the same annually at the first meeting of the Council, and shall pay over to the Treasurer such unexpended funds as the Council may direct. He shall receive and hold in trust for the Association all books, pamphlets, and manuscripts belonging to the Association, and allow the use of the same under the provisions of the Constitution and the orders of the Council. He shall receive all communications addressed to the Association during the intervals between meetings, and properly attend to the same. He shall at each meeting report the names of fellows and members who have died since the preceding meeting. He shall be allowed a salary which shall be determined by the Council, and may employ one or more clerks at such compensation as may be agreed upon by the Council.

Treasurer.

Art. 15. The Treasurer shall invest the funds received by him in such securities as may be directed by the Council. He shall annually present to the Council an account of the funds in his charge. No expenditure of the principal in the hands of the Treasurer shall be made without a unanimous vote of the Council, and no expenditure of the income received by the Treasurer shall be made without a two-thirds vote of the Council. The Treasurer shall give bonds for the faithful performance of his duty in such manner and sum as the Council shall from time to time direct.

Secretaries of the Sections.

Art. 16. The Secretaries of the Sections shall keep the records of their respective Sections, and, at the close of the meeting, give the same, including the records of subsections, to the General Secretary. They shall also be the Secretaries of the sectional committees. The Secretaries shall have seniority in order of their continuous membership in the Association.

Vacancies.

Art. 17. In case of a vacancy in the office of President, the senior Vice-President shall preside, as provided in Article 10,

until the General Committee can be assembled and the vacancy filled by election. Vacancies in the offices of Vice-President, Permanent Secretary, Secretary of the Council, Secretaries of the Sections, and Treasurer, shall be filled by the Council by ballot.

COUNCIL.

ART. 18. The Council shall consist of the Past Presidents, and the Vice-Presidents of the last two meetings, together with the President, the Vice-Presidents, the Permanent Secretary, the General Secretary, the Secretary of the Council, the Secretaries of the Sections, and the Treasurer of the current meeting, of one fellow elected from each Section by ballot on the first day of its meeting, of one fellow elected by each affiliated society, and one additional fellow from each affiliated society having more than twenty-five members who are fellows of the Association, and of nine fellows elected by the Council, three being annually elected for a term of three years. The members present at any regularly called meeting of the Council, provided there are at least five, shall form a quorum for the transaction of business. The Council shall meet on the day preceding each annual meeting of the Association, and arrange the program for the first day of the sessions. The time and place of this first meeting shall be designated by the Permanent Secretary. Unless otherwise agreed upon, regular meetings of the Council shall be held in the Council room at 9 o'clock A. M., on each day of the meeting of the Association. Special meetings of the Council may be called at any time by the President. The Council shall be the board of supervision of the Association, and no business shall be transacted by the Association that has not first been referred to, or originated with, the Council. The Council shall decide which papers, discussions, and other proceedings shall be published, and have the general direction of the publications of the Association; manage the financial affairs of the Association; arrange the business and programs for General Sessions; suggest subjects for discussion, investigation or reports; elect members and fellows; and receive and act upon all invitations extended to the Association and report the same at a General Session of the Association. The Council shall receive all reports of Special Committees and decide upon them, and only such shall be read in General

Session as the Council shall direct. The Council shall appoint at each meeting the following subcommittees who shall act, subject to appeal to the whole Council, until their successors are appointed at the following meeting: 1, on Papers and Reports; 2, on Members; 3, on Fellows.

GENERAL COMMITTEE.

ART. 19. The General Committee shall consist of the Council and one member or fellow elected by each of the Sections, who shall serve until their successors are elected. It shall be the duty of the committee to meet at the call of the President and elect the general officers for the following meeting of the Association. It shall also be the duty of this committee to fix the time and place for the next meeting. The Vice-President and Secretary of each Section shall be recommended to the General Committee by the Sectional Committee.

MEETINGS.

ART. 20. The Association shall hold a public meeting annually, for one week or longer, at such time and place as may be determined by vote of the General Committee, and the preliminary arrangements for each meeting shall be made by the Local Committee, in conjunction with the Permanent Secretary and such other persons as the Council may designate.

But if suitable preliminary arrangements cannot be made, the Council may afterward change the time and place appointed by the General Committee, if such change is believed advisable, by two-thirds of the members present.

ART. 21. A General Session shall be held at 10 o'clock, A. M., on the first day of the meeting, and at such other times as the Council may direct.

SECTIONS AND SUBSECTIONS.

ART. 22. The Association shall be divided into Sections, namely:—A, *Mathematics and Astronomy;* B, *Physics;* C, *Chemistry, including its application to Agriculture and the Arts;* D, *Mechanical Science and Engineering;* E, *Geology and Geography;* F, *Zoology;* G, *Botany;* H, *Anthropology;* I, *Social and Economic Science;* K, *Physiology and Experimental Medicine.* The Council shall have

power to consolidate any two or more Sections temporarily, and such consolidated Sections shall be presided over by the senior Vice-President and Secretary of the Sections comprising it.

SECTIONAL COMMITTEES.

ART. 23. Immediately on the organization of a Section there shall be a member or fellow elected by ballot after open nomination, who, with the Vice-President and Secretary and the Vice-President and Secretary of the preceding meeting, and the members or fellows elected by ballot at the four preceding meetings, shall form its Sectional Committee. The Sectional Committees shall have power to fill vacancies in their own numbers. Meetings of the Sections shall not be held at the same time with a General Session. The Sectional Committee may invite distinguished foreign associates present at any meeting to serve as honorary members of said Committee.

ART. 24. The Sectional Committee of any Section may at its pleasure form one or more temporary Subsections, and may designate the officers thereof. The Secretary of a Subsection shall, at the close of the meeting, transmit his records to the Secretary of the Section.

ART. 25. No paper shall be read in any Section or Subsection until it has been placed on the program of the day by the Sectional Committee.

ART. 26. The Sectional Committees shall arrange and direct the business of their respective Sections. They shall prepare the daily programs and give them to the Permanent Secretary for printing at the earliest moment practicable. No titles of papers shall be entered on the daily programs except such as have passed the Committee. No change shall be made in the program for the day in a Section without the consent of the Sectional Committee. The Sectional Committees may refuse to place the title of any paper on the program; but every such title, with the abstract of the paper or the paper itself, must be referred to the Council with the reasons why it was refused. The Sectional Committee shall also make nominations to the General Committee for Vice-President and Secretary of their respective Sections as provided for in Article 19.

ART. 27. The Sectional Committees shall examine all papers and abstracts referred to the Sections, and they shall not place

on the program any paper inconsistent with the character of the Association; and to this end they have power to call for any paper, the character of which may not be sufficiently understood from the abstract submitted.

PAPERS AND COMMUNICATIONS.

ART. 28. All members and fellows must forward to the Secretary of the proper Section or to the Permanent Secretary, as early as possible. and when practicable before the convening of the Association, full titles of all the papers which they propose to present during the meeting, with a statement of the time that each will occupy in delivery, and also such abstracts of their contents as will give a general idea of their nature; and no title shall be considered by a Sectional Committee until an abstract of the paper or the paper itself has been received.

ART. 29. If the author of any paper be not ready when called upon, in the regular order of the official program, the title may be dropped to the bottom of the list.

ART. 30. Whenever practicable the proceedings and discussions at General Sessions, Sections and Subsections, shall be reported by professional reporters, but such reports shall not appear in print as the official reports of the Association unless revised by the Secretaries.

PRINTED PROCEEDINGS.

ART. 31. The Permanent Secretary shall have the Proceedings of each meeting printed in an octavo volume as soon after the meeting as possible, beginning one month after adjournment. Authors must prepare their papers or abstracts ready for the press, and these must be in the hands of the Secretaries of the Sections before the final adjournment of the meeting, otherwise only the titles will appear in the printed volume. The Council shall have power to order the printing of any paper by abstract or title only. Whenever practicable, proofs shall be forwarded to authors for revision. If any additions or substantial alterations are made by the author of a paper after its submission to the Secretary, the same shall be distinctly indicated. Illustrations must be provided for by the authors of the papers, or by a special appropriation from the Council. Immediately on publication of

the volume, a copy shall be forwarded to every member and fellow of the Association who shall have paid the assessment for the meeting to which it relates, and it shall also be offered for sale by the Permanent Secretary at such price as may be determined by the Council. The Council shall also designate the institutions to which copies shall be distributed.

LOCAL COMMITTEE.

ART. 32. The Local Committee shall consist of persons interested in the objects of the Association and residing at or near the place of the proposed meeting. It is expected that the Local Committee, assisted by the officers of the Association, will make all essential arrangements for the meeting, and issue a circular giving necessary particulars, at least one month before the meeting.

LIBRARY OF THE ASSOCIATION.

ART. 33. All books and pamphlets received by the Association shall be in charge of the Permanent Secretary, who shall have a list of the same printed and shall furnish a copy to any member or fellow on application. Members and fellows who have paid their assessments in full shall be allowed to call for books and pamphlets, which shall be delivered to them at their expense on their giving a receipt agreeing to make good any loss or damage, and to return the same free of expense to the Secretary at the time specified in the receipt given. All books and pamphlets in circulation must be returned at each meeting. Not more than five books, including volumes, parts of volumes, and pamphlets, shall be held at one time by any member or fellow. Any book may be withheld from circulation by order of the Council. [The Library of the Association was, by vote of the Council in 1895, placed on deposit in the Library of the University of Cincinnati, Ohio. Members can obtain the use of books by writing to the Librarian of the University Library, Cincinnati, Ohio.]

ADMISSION FEE AND ASSESSMENTS.

ART. 34. The admission fee for members shall be five dollars in addition to the annual dues. On the election of any member as a fellow an additional fee of two dollars shall be paid.

ART. 35. The annual dues for members and fellows shall be three dollars.

ART. 36. Any member or fellow who shall pay the sum of fifty dollars to the Association, at any one time, shall become a Life Member, and as such shall be exempt from all further assessments, and shall be entitled to the Proceedings of the Association. All money thus received shall be invested as a permanent fund, the income of which, during the life of the member, shall form a part of the general fund of the Association; but, after his death, shall be used only to assist in original research, unless otherwise directed by unanimous vote of the Council.

ART. 37. All fees and dues must be paid to the Permanent Secretary, who shall give proper receipts for the same.

ACCOUNTS.

ART. 38. The accounts of the Permanent Secretary and of the Treasurer shall be audited annually by Auditors appointed by the Council.

ALTERATIONS OF THE CONSTITUTION.

ART. 39. No part of this Constitution shall be amended or annulled, without the concurrence of three-fourths of the members and fellows present in General Session, after notice given at a General Session of a preceding meeting of the Association.

MEMBERS AND FELLOWS

OF THE

AMERICAN ASSOCIATION

FOR THE

ADVANCEMENT OF SCIENCE.

(CORRECTED TO APRIL 1, 1904.)

SURVIVING FOUNDERS.

[At the Brooklyn Meeting, 1894, a resolution was unanimously adopted by which all the surviving founders of the Association who have maintained an interest in science were made Honorary Life Members of the Association in recognition of their pioneer work in American Science.]

ABBOT, SAMUEL L., Boston, Mass.
BOYÉ, MARTIN H., Coopersburg, Pa.
GIBBS, WOLCOTT, Newport, R. I.

PATRONS.

[Persons contributing one thousand dollars or more to the Association are classed as Patrons, and are entitled to the privileges of members and to the publications. The names of Patrons are to remain permanently on the list.]

THOMPSON, MRS. ELIZABETH, Stamford, Conn. (22). (Died July, 1899.)
LILLY, GEN. WILLIAM, Mauch Chunk, Pa. (28). (Died Dec. 1, 1893.)
HERRMAN, MRS. ESTHER, 59 West 56th St., New York, N. Y. (29).
McMILLIN, EMERSON, 40 Wall St., New York, N. Y. (37).

HONORARY FELLOWS.

[See ARTICLE VI of the Constitution.]

*ROGERS, PROF. WILLIAM B., Boston, Mass. (1). 1881. (Born Dec. 7, 1804. Died May 30, 1882.) **B E**
*CHEVREUL, MICHEL EUGENE, Paris, France. (35). 1886. (Born Aug. 31, 1786. Died April 9, 1889.) **C**
*GENTH, DR. F. A., Philadelphia, Pa. (24). 1888. (Born May 17, 1820. Died Feb. 2, 1892.) **C E**

*Hall, Prof. James, Albany, N. Y. (1). 1890. (Born in 1811. Died Aug. 7, 1898.)

*Gould, Dr. Benjamin Apthorp, Cambridge, Mass. (2). 1895. (Born Sept. 27, 1824. Died Nov. 26, 1896.) **A B**

*Leuckart, Prof. Rudolf. (44). 1895. (Born in Helmstedt, Braunschweig, Germany, Oct. 7, 1823. Died in Leipzig, Feb. 7, 1898.) **F**

*Gibbs, Prof. Wolcott, Newport, R. I. (1). 1896. **B C**

*Warington, Robert, F. R. S., Rothamsted, Harpenden, England. (40). 1899. **C**

*Westinghouse, George, Pittsburg, Pa. (50). 1902. **D**

MEMBERS AND FELLOWS.

The names designated by an asterisk (*) are those of Fellows. (See Article IV of the Constitution.) The number in parenthesis indicates the meeting at which the Member joined the Association; the date following is the year when made a Fellow; the black letters at end of line are those of the Sections to which the Member or Fellow belongs. When the name is given in small capitals, it designates that the Member or Fellow is also a Life Member. Any Member or Fellow may become a Life Member by the payment of fifty dollars. The income of the money derived from a life membership is used for the general purposes of the Association during the life of the Member; afterwards it is to be used to aid in original research. Life Members are exempt from the annual assessment, and are entitled to the publications. The names of Life Members are printed in small capitals in the regular list of Members and Fellows.

The Constitution requires that the names of all Members two years in arrears shall be omitted from the list, but their names will be restored on payment of arrearages. Members not in arrears are entitled to the publications of the Association, including the journal *Science*.

*Abbe, Cleveland, Professor of Meteorology, Weather Bureau, U. S. Dept. Agriculture, Washington, D. C. (16). 1874. **A B**

*Abbe, Cleveland, Jr., U. S. Geological Survey, Washington, D. C. (44). 1899. **E**

Abbe, Truman, M. D., 2017 I St., N. W., Washington, D. C. (52). **K**

*Abbe, Dr. Robert, 13 W. 50th St., New York, N. Y. (36). 1892.

*Abbot, Charles G., Smithsonian Institution, Washington, D. C. (49). 1902. **B**

*Abbot, Dr. Samuel L., 90 Mt. Vernon St., Boston, Mass. (1). 1898.

Abbott, Alexander C., Univ. of Penna., Philadelphia, Pa. (52). **K**

Abbott, Frank L., Professor of Physical Science, State Normal School, Greeley, Colo. (50). **B E**

Abbott, Theodore Sperry, C. E., Saltillo, Coahuila, Mexico. (52). **D**

*Abel, John J., Professor of Pharmacology, Johns Hopkins University, Baltimore, Md. (51). 1902. **C**

Abraham, Abraham, Brooklyn, N. Y. (43).

*Acheson, Edward Goodrich, President of the International Acheson Graphite Co., Niagara Falls, N. Y. (50). 1903. C

*Adams, Charles C., University of Michigan, Ann Arbor, Mich. (50). 1903. F

Adams, Charles Francis, Head of Science Department, Central High School, Detroit, Mich. (53). B

Adams, Comfort A., 13 Farrar St., Cambridge, Mass. (47).

Adams, C. E., M. D., 29 West Broadway, Bangor, Me. (43). F

Adams, Edward Dean, 35 Wall St., New York, N. Y. (49).

Adams, Frederick C., Mechanic Arts High School, Boston, Mass. (50). B C

Adams, Orr J., Telluride, Colo. (53). G

*Adler, Isaac, M. D., 22 E. 62d St., New York, N. Y. (49). 1903. K

*Adriance, John S., 105 E. 39th St., New York, N. Y. (39). 1895. C

Aguilera, José G., Director of the Geological Institute of Mexico, Mexico City, Mexico. (53). E

Ailes, Hon. Milton E., Riggs National Bank, Washington, D. C. (52). I

Ainsworth, Herman Reeve, M. D., Addison, N. Y. (51). I K

Aitken, Robert G., Lick Observatory, Mt. Hamilton, Cal. (53) A

Akeley, Lewis E., Professor of Physics and Chemistry, University of South Dakota, Vermillion, S. Dak. (51). B C

Albaugh, Maurice, Secretary of the Crescent Metallic Fence Stay Co., Covington, Ohio. (51). D

Albert, Harry Lee, Professor of Biology, State Normal School, Cape Girardeau, Mo. (53). F G

Albrecht, Emil Poole, Secretary of The Bourse, 1523 N. 17th St., Philadelphia, Pa. (51). A D

Albrecht, Sebastian, Lick Observatory, Mt. Hamilton, Cal. (52). A

Albree, Chester B., Mechanical Engineer, 14–30 Market St., Allegheny, Pa. (50). D

*Alden, John, Pacific Mills, Lawrence, Mass. (36). 1898.

*Alderson, Victor C., President Colorado School of Mines, Golden, Colorado. (50). 1903. D

*Aldrich, Wm. S., Director, Thomas S. Clarkson Memorial School of Technology, Potsdam, N. Y. (43). 1897. D

Alexander, Chas. Anderson, M. E., Johnston Harvester Co., 10 Vine St., Batavia, N. Y. (50). D

Alexander, Curtis, Mining Engineer, Cedral, San Luis Potosi, Mexico. (50). E

Alexander, George E., Chemist and Mining Engineer, 1736 Champa St., Denver, Colo. (50). C D

Alexander, Harry, E. E., M. E., 18 and 20 W. 34th St., New York, N. Y. (50). D

Aley, Robert J., Indiana Univ., Bloomington, Ind. (49).

Allabach, Miss Lulu F., Instructor in Biology and Zoology. Central State Normal School, Lock Haven, Pa. (52). F

Allan, Chas. F., Newburgh. N. Y. (50). B E

Allderdice, Wm. H., Lieutenant U. S. Navy, Navy Dept., Washington, D. C. (33). D

Alleman, Gellert, Ph. D., Swarthmore College, Swarthmore, Pa. (50). C

Allen, C. L., Floral Park, N. Y. (49).

Allen, Charles Metcalf, Assistant Prof. of Experimental Engineering, Worcester Polytechnic Institute, Worcester, Mass. (52). D

Allen, Edwin West, Editor of *Experiment Station Record*, U. S. Dept. Agriculture, Washington, D. C. (52). I

*Allen, Frank, Ph. D., Cornell University, Ithaca, N. Y. (49). 1903. B

Allen, Hon. F. I., Commissioner of Patents, Washington, D. C. (52). I

Allen, Glover Morrill, Secretary Boston Soc. Nat. Hist., Perkins Hall 68, Cambridge, Mass. (52). F

Allen, H. Jerome, M. D., 421 H St., N.E., Washington, D. C. (51). K

Allen, Miss Jessie Blount, Univ. of Chicago, Chicago, Ill. (52). F

Allen, John Robins, Asst. Prof. of Mechanical Engineering, University of Michigan, Ann Arbor, Mich. (45). B D

Allen, Richard H., Chatham, N. J. (49).

Allen, Walter S., 34 S. Sixth St., New Bedford, Mass. (39). C I

Allis, Edward Phelps, Jr., Palais Carnolès, Menton, France. (52). F

Allison, Charles Edward, M. D., Elysburg, Pa. (51). K

Allison, Hendery, M. D., 260 West 57th St., New York, N.Y. (50). K

Almond, Thomas R., M. E., 83–85 Washington St., Brooklyn, N. Y. (51). D

*Almy, John E., Ph. D., Instructor in Physics, University of Nebraska, Lincoln, Neb. (50). 1901. B

Alpers, Wm. C., 45 West 31st St., New York, N. Y. (50). I

Alsop, E. B., 1502 20th St., N. W., Washington, D. C. (50). D

Alspach, E. F., 455 West Sixth Ave., Columbus, O. (48). H

Alt, Adolf, M. D., 3819 W. Pine Boulevard, St. Louis, Mo. (53). F

*Alvord, Maj. Henry E., U. S. Dept. Agriculture, Washington, D. C. (29). 1882. I

*Alwood, Prof. Wm. B., Virginia Polytechnic Institute, Blacksburg, Va. (39). 1891. F

Ames, Oakes, Assistant Director of the Botanic Garden of Harvard University, North Easton, Mass. (50). G

Amweg, Frederick James, Engineer and Manager, American-Hawaiian Engineering and Construction Co., Ltd., 218–222 Rialto Building, San Francisco, Cal. (51). D

Anders, Howard S., M. D., 1836 Wallace St., Philadelphia, Pa. (51). **K**

Anderson, A. J. C., 127 Water St., New York, N. Y. (49).

*Anderson, Alexander P., American Cereal Co., Monadnock Building, Chicago, Ill. (45). 1899. **G**

Anderson, Prof. Douglas S., Tulane Univ., New Orleans, La. (49). **B D**

Anderson, Edwin Clinton, M. D., 726 Market St., Chattanooga, Tenn. (51). **K**

Anderson, Frank, E. M., 255 Second East St., Salt Lake City, Utah. (50). **D E**

Anderson, Frank P., Epworth, Iowa. (46).

Anderson, J. Hartley, M. D., 4630 Fifth Ave., Pittsburg, Pa. (50). **K**

Anderson, James Thomas, Lieutenant U. S. Army, 1421 Wood Ave., Colorado Springs, Colo. (51).

Anderson, William G., M. D., Associate Director Yale Gymnasium, New Haven, Conn. (52). **H K**

Anderson, Winslow, M. D., President of College of Physicians and Surgeons of San Francisco, 1025 Sutter St., San Francisco, Cal. (51). **K**

Andrews, Clement Walker, Librarian of The John Crerar Library, Chicago, Ill. (53). **C**

*Andrews, Frank Marion, Ph. D., Instructor in Botany, Indiana University, Bloomington, Ind. (52). 1903. **G**

Andrews, Wm. Edward, Principal Township High School, 700 South Clay St., Taylorville, Ill. (52). **D**

Andrews, William Symes, care Gen'l Elec. Co., Schenectady, N. Y. (50). **D E**

Annear, John Brothers, 1028 Regent St., Boulder, Colo. (50). **C**

Anthony, Mrs. Emilia C., Gouverneur, N. Y. (47). **G**

Anthony, Richard A., 122–124 Fifth Ave., New York, N. Y. (49).

*Anthony, Prof. Wm. A., Cooper Union, New York, N. Y. (28). 1880. **B**

Apple, Joseph H., President of the Woman's College, Frederick, Md. (52). **I**

*Appleton, John Howard, Professor of Chemistry, Brown University, Providence, R. I. (50). 1901. **C**

Archer, George Frost, 31 Burling Slip, New York, N. Y. (50). **D**

Armitage, Thomas L., M. D., Princeton, Minnesota. (51). **K**

*Armsby, Henry Prentiss, Director Agrl. Expr. Station, State College, Centre Co., Pa. (52). 1903. **C**

*Arnold, Bion Joseph, 4128 Prairie Ave., Chicago, Ill. (50). 1903. **D**

Arnold, Delos, Olcott Place, Pasadena, Cal. (51).

Arnold, Ernst Hermann, M. D., Director New Haven Normal School of Gymnastics, 46 York Square, New Haven, Conn. (52). K

Arnold, Mrs. Francis B., 101 W. 78th St., New York, N. Y. (49).

Arnold, Jacob H., Teacher of Natural Science, Redfield College, Redfield, South Dakota. (50). I

Arnold, Ralph, U. S. Geological Survey, Washington, D. C. (51). E

*Arthur, J. C., D. Sc., Botanist Agric. Exper. Sta., Purdue Univ., Lafayette, Ind. (21). 1883. G

Asdale, William James, M. D., Professor of Gynecology, Western Penna. Medical College, Pittsburg, Pa. (51). K

Ashbrook, Donald Sinclair, 3614 Baring St., Philadelphia, Pa. (51). C

Ashcraft, A. M., Ph.D., P. O. Box 742, Baltimore, Md. (52).

Ashe, W. Willard, Consulting Forester, Raleigh, N. C. (47).

*Ashley, George Hall, Professor of Biology and Geology, College of Charleston, Charleston, S. C. (51). 1903. E F

*Ashmead, Wm. H., Department of Insects, U. S. National Museum, Washington, D. C. (40). 1892. F

Ashton, Charles Hamilton, Assistant in Mathematics, University of Kansas, Lawrence, Kansas. (53). A

Aspinwall, John, 290 Broadway, New York, N. Y. (49).

Atkins, Prof. Martin D., 269 Forest Ave., River Forest, Ill. (48). B

*Atkinson, Edward, 31 Milk St., Boston, Mass. (29). 1881. D I

*Atkinson, George F., Cornell University, Ithaca, N. Y. (39). 1892. G

Atkinson, John B., Earlington, Ky. (26). D

*Atwater, W. O., Professor of Chemistry, Wesleyan Univ., Middletown, Conn. (29). 1882. C

*Atwell, Charles B., Northwestern Univ., Evanston, Ill. (36). 1890. G

*Auchincloss, Wm. S., Atlantic Highlands, N. J. (29). 1886. A D

*Austen, Prof. Peter T., 80 Broad St., New York, N. Y. (44). 1896. C

Austin, Oscar P., Chief Bureau of Statistics, Washington, D. C. (51). I

*Avery, Elroy M., Ph. D., LL.D., 657 Woodland Hills Ave., Cleveland, Ohio. (37). 1889. B

AVERY, SAMUEL P., 4 E. 38th St., New York, N. Y. (36).

Avis, Edward S., Ph. D., President North Georgia Agricultural College, Dahlonega, Ga. (52).

Ayer, Edward Everett, 915 Old Colony Bldg., Chicago, Ill. (37). H

Ayer, James I., 5 Main St. Park, Malden, Mass. (50). D

*Ayers, Howard, President Univ. of Cincinnati, Cincinnati, Ohio. (49). 1901. F

Aylesworth, Barton O., President of the State Agricultural College, Fort Collins, Colo. (50). I

*Ayres, Prof. Brown, Tulane University, New Orleans, La. (31). 1885. B

Ayres, Horace B., U. S. Geological Survey, Washington, D. C. (40).

Babcock, Charles A., Supt. Schools, Oil City, Pa. (52). F

*Babcock, Prof. S. Moulton, 432 Lake St., Madison, Wis. (33). 1885. C

Bacon, Arthur Avery, Professor of Physics, Hobart College, Geneva, N. Y. (53). B

Baerecke, John F., M. D., Professor of Biology, Stetson University, DeLand, Fla. (50). F K

Bagby, J. H. C., Dept. Physical Science, Hampden-Sidney College, Hampden-Sidney, Va. (50). B

*Bagg, Rufus Mather, Jr., Ph. D., High School, Brockton, Mass. (49). 1903. E

Baggaley, Ralph, Pittsburg, Pa. (50). D

*Bailey, E. H. S., Professor of Chemistry, Univ. of Kansas, Lawrence, Kan. (25). 1889. C E

Bailey, E. P., In charge Department of Geology and Geography, Brockton High School, Brockton, Mass. (52). E

Bailey, Frank H., Lieut. Com'dr, U. S. N., U. S. F. S. "Brooklyn," care of Postmaster, New York, N. Y. (52). D

*Bailey, Solon Irving, Associate Prof. Astronomy, Harvard Observatory, Cambridge, Mass. (50). 1901. A

Bailey, Vernon, Department of Agriculture, Washington, D. C. (52). F

*Bain, Samuel M., Professor of Botany, University of Tennessee, Knoxville, Tenn. (50). 1902. G

Bair, Joseph Hershey, Ph. D., Columbia University, New York, N. Y. (52). H K

Baird, John Wallace, Carnegie Research Assistant in Psychology, Cornell University, Ithaca, N. Y. (53). H

Baird, Robert Logan, Assistant in Laboratories, Oberlin College, Oberlin, Ohio. (53). F

Baker, A. G., Springfield, Mass. (44).

*Baker, Frank, M. D., 1728 Columbia Road, Washington, D. C. (31). 1886. F H K

Baker, Frederic, 815 Fifth Ave., New York, N. Y. (40).

Baker, Hugh P., Yale Forest School, New Haven, Conn. (51). G

*Baker, James H., President of the University of Colorado, Boulder, Colo. (50). 1903. I

Balch, Alfred William, Assistant Surgeon, U. S. N., Navy Department, Washington, D. C. (52). C K

*BALCH, EDWIN SWIFT, 1412 Spruce St., Philadelphia, Pa. (51). 1903. E H

Balch, Francis Noyes, Prince St., Jamaica Plain, Mass. (50). F

Balch, Samuel W., 67 Wall St., New York, N. Y. (43).

Baldwin, Mrs. G. H., 3 Madison Ave., Detroit, Mich. (34). H

Baldwin, Herbert B., 9–11 Franklin St., Newark, N. J. (43).

*Baldwin, Prof. J. Mark, Princeton, N. J. (46). 1898. H

*BALDWIN, HON. SIMEON E., Associate Judge of Supreme Court of Errors, New Haven, Conn. (50). 1901. I

*BALDWIN, S. PRENTISS, 736 Prospect St., Cleveland, Ohio. (47). 1900. E

Baldwin, William Dickson, 25 Grant Place, Washington, D. C. (52). E

*Ball, Carleton R., U. S. Dept. Agriculture, Washington, D. C. (49). 1902. G

*Ball, Elmer Darwin, Professor of Animal Biology, State Agricultural College, Logan, Utah. (50). 1903. F

Ball, Miss Helen Augusta, 43 Laurel St., Worcester, Mass. (50). F

Ballard, C. A., Curator of Museum, State Normal School, Moorhead, Minn. (51).

*Ballard, Harlan H., 50 South St., Pittsfield, Mass. (31). 1891. E F

*Balliet, Thomas M., Supt. of Schools, Springfield, Mass. (48). 1903. H I

Bancroft, Alonzo C., Elma, New York. (41).

Bancroft, Frank Watts, Ph. D., Instructor in Physiology, University of California, Berkeley, Cal. (50). F K

Bancroft, John Sellers, M. E., 3310 Arch St., Philadelphia, Pa. (51). D

*Bancroft, Wilder Dwight, Professor of Chemistry, Cornell University, Ithaca, N. Y. (50). 1901. B C

BANGS, LEMUEL BOLTON, M. D., 39 E. 72d St., New York, N. Y. (36).

*Bangs, Outram, 240 Beacon St., Boston, Mass. (47). 1900. F

Banker, Howard J., Prof. Biology, Southwestern Normal School, California, Pa. (51). G

Banks, William C., Electrician, Gordon Battery Co., 439 E. 144th St., New York, N. Y. (50). D

Banta, Arthur M., Univ. of Indiana, Bloomington, Ind. (53). F

Barber, Amzi L., 7 E. 42d St., New York, N. Y. (49).

Barbour, Miss Carrie Adeline, Dept. of Geology, Univ. of Nebraska, Lincoln, Neb. (53). E

*Barbour, Erwin Hinckley, Prof. of Geology, Univ. of Nebraska, Lincoln, Neb. (45). 1898. E

Barbour, Thomas, 50 White St., New York, N. Y. (50). **F**
Barck, Dr. Carl, 2715 Locust St., St. Louis, Mo. (52).
*Bardeen, Charles Russell, Anatomical Laboratory, Wolfe and Monument Sts., Baltimore, Md. (50). 1901. **F K**
Bardeen, Charles William, 406 So. Franklin St., Syracuse, N. Y. (52).
Bardwell, Darwin L., District Supt. of Schools, Borough of Richmond, Stapleton, N. Y. (52).
Barkan, Adolph, M. D., LL.D., Mutual Savings Bank Bldg., San Francisco, Cal. (51). **K**
*BARKER, PROF. G. F., 3909 Locust St., Philadelphia, Pa. (13). 1875. **B C**
Barker, Mrs. Martha M., 42 Eleventh St., Lowell, Mass. (31). **E H**
Barlow, John, A. M., State College of Agriculture, Kingston, R. I. (51). **F**
*Barnard, Edward E., Yerkes Observatory, Williams Bay, Wis. (26). 1883. **A**
Barnes, Albert, Clemson College, S. C. (49). **D**
*Barnes, Charles Reid, Ph. D., Univ. of Chicago, Chicago, Ill. (33). 1885. **G**
Barnes, Edward W., Box 446, New York, N. Y. (49).
Barnett, Robert Crary, 3023 East 20th St., Kansas City, Mo. (51). **D**
Barnhart, Arthur M., 185 Monroe St., Chicago, Ill. (42).
*Barnhart, John H., M. D., Tarrytown, N. Y. (49). 1903. **G**
Barnsley, George Thomas, C. E., Oakmont, Pa. (51). **D**
*Barnum, Miss Charlotte C., Ph. D., U. S. Coast and Geodetic Survey, Washington, D. C. (36). 1896. **A**
Barr, Charles Elisha, Professor of Biology, Albion College, Albion, Mich. (50). **F**
*Barr, John Henry, care of Smith Premier Typewriter Co., Syracuse, N. Y. (51). 1903. **D**
Barrell, Joseph, 105 Bishop St., New Haven, Conn. (51). **E**
Barrie, Dr. George, Johns Hopkins Univ., Baltimore, Md. (49). **H I**
Barringer, Daniel Moreau, Geologist and Mining Engineer, 460 Bullitt Building, Philadelphia, Pa. (50). **D E**
*Barrows, Walter B., Agricultural College, Mich. (40). 1897. **F**
*Bartlett, Prof. Edwin J., Dartmouth College, Hanover, N. H. (28). 1883. **C**
Bartlett, Francis, 40 State St., Boston, Mass. (50). **I**
Bartlett, George Miller, Instructor in Physics and Mathematics, University of Michigan, Ann Arbor, Mich. (52). **B**
*Bartlett, John R., Captain, U. S. N., Lonsdale, R. I. (30). 1882. **B E**

*Bartley, Elias H., M. D., 21 Lafayette Ave., Brooklyn, N. Y. (33). 1894. C

*Barton, G. E., 212 North 3d St., Millville, N. J. (46). 1898. C

*Barton, George Hunt, Dept. of Geology, Mass. Inst. Tech., Boston, Mass. (47). 1900. E

Barton, Philip Price, E. E., Sup't Niagara Falls Power Co., 127 Buffalo Ave., Niagara Falls, N. Y. (50). D E

*Barton, Samuel M., Ph. D., The Univ. of the South, Sewanee, Tenn. (43). 1899. A

Bartow, Edward, Ph. D., Kansas State University, Lawrence, Kan. (47). C

Bartsch, Paul, Ph. D., Instructor in Zoology, Columbian Univ., Washington, D. C. (52). F

*Barus, Carl, Ph. D., Wilson Hall, Brown Univ., Providence, R. I. (33). 1887. B

Barwell, John William, Waukegan, Ill. (47).

*Bascom, Miss Florence, Bryn Mawr College, Bryn Mawr, Pa. (42). 1897. E

Bashore, Dr. Harvey B., West Fairview, Pa. (46). E

*Baskerville, Charles, Professor of Chemistry, University of North Carolina, Chapel Hill, N. C. (41). 1894. C E

Baskett, James Newton, Mexico, Mo. (50). F I

Basquin, Olin H., Associate Piofessor of Physics, Northwestern University, Evanston, Ill. (53). B D

Bassett, Carroll Phillips, Ph. D., Civil and Consulting Engineer, Summit, N. J. (51). D

Bates, Henry H., Ph. D., The Portland, Washington, D. C. (52). A B D

Bates, Rev. John Mallery, Red Cloud, Neb. (51). G I

Bauder, Arthur Russell, Instructor in Physics, Boardman High School, New Haven, Conn. (50). B

*Bauer, Louis A., Ph. D., U. S. C. and G. Survey, Washington, D. C. (40). 1892. A

Baumgardt, B. R., 626 W. 30th Street, Los Angeles, Cal. (51). A

*Bausch, Edw., P. O. Drawer 1033, Rochester, N. Y. (26). 1883. A B C F

Bausch, Henry, P. O. Drawer 1033, Rochester, N. Y. (41).

Bawden, H. Heath, Professor of Psychology and Philosophy, Vassar College, Poughkeepsie, N. Y. (51). F

Baxter, James Phinney, President, Maine Historical Society, Portland, Maine. (50). H I

Beach, Miss Alice M., St. Anthony Park, Minn. (50). F

Beach, Charles Coffing, M. D., 54 Woodland St., Hartford, Conn. (50). F K

Beach, Henry Harris Aubrey, M. D., 28 Commonwealth Ave., Boston, Mass. (50). F K

*Beach, Spencer Ambrose, N. Y. Agric. Exper. Station. Geneva, N. Y. (41). 1900. G

Beach, William Harrison, Teacher of History and Civics, East Division High School, 229 Pleasant St., Milwaukee, Wis. (52).

Beahan, Willard, Division Engineer, C. & N. W. Ry., 220 W. 6th St., Winona, Minn. (51). D

Beal, Walter Henry, Assistant, Office of Experiment Stations. U. S. Dept. Agriculture. Washington, D. C. (52).

*Beal, Wm. James, Ph. D., Professor of Botany, Agricultural College, Mich. (17). 1880. G

Beaman, George Herbert, 2232 Mass. Ave., N.W., Washington, D. C. (52). I

*Beardsley, Arthur E., Professor of Biology, Colorado State Normal School, Greeley, Colo. (50). 1901. F

Beates, Henry, Jr., M. D., President of State Board of Medical Examiners, 1504 Walnut St., Philadelphia, Pa. (51). K

Beatty, James W. F., Pitcairn, Pa. (51).

Bebb, Edward C., U. S. Geological Survey, Washington, D. C. (52). E

Becher, Franklin A., 234 Oneida St., Milwaukee, Wis. (41). A I

Beck, Carl, M. D., Professor of Surgery in New York Postgraduate Medical School and President of St. Mark's Hospital, 37 E. 31st St., New York, N. Y. (51). K

*Becker, Dr. Geo. F., U. S. Geol. Survey, Washington, D. C. (36). 1890. E

Beckwith, Miss Florence, 394 Alexander St., Rochester, N. Y. (45). G

*Bedell, Frederick, Ph. D., Cornell Univ., Ithaca, N. Y. (41). 1894. A B

Beebe, Charles William, Curator of Ornithology, N. Y. Zoological Park, New York, N. Y. (53). F

Beede, Joshua William, Indiana University, Bloomington, Ind. (50). E

Beekman, Gerard, 47 Cedar St., New York, N. Y. (49).

Beers, M. H., 410 Broadway, New York, N. Y. (50). I

*Behrend, Bernhard Arthur, C. E., E. E., Station H, Cincinnati, Ohio. (50). 1903. D E

*Bell, Alex. Graham, Ph. D., 1331 Conn. Ave., N.W., Washington, D. C. (26). 1879. B H I

*Bell, Alex. Melville, 1525 35th St., Washington, D. C. (31). 1885. H

*Bell, Albert T., Professor of Botany, Wesleyan Univ., University Place, Neb. (52). 1903. G

BELL, C. M., M. D., 320 Fifth Ave., New York, N. Y. (36).

Bell, George, Mineralogist, 200 S. Washington Ave., Denver, Colo. (50). **E G**

Bell, Guido, M. D., 431 E. Ohio St., Indianapolis, Ind. (51). **K**

Bell, John Everett, M. E., care of The Stirling Co., Barberton, Ohio. (53). **D**

*Bell, Robert, M. D., LL.D., F. R. S., Geol. Survey, Ottawa, Can. (38). 1889. **E F**

Bellows, Horace M., M. D., Huntingdon Valley, Pa. (51). **K**

Belmont, August, 23 Nassau St., New York, N. Y. (50). **I**

*Beman, Wooster W., 813 E. Kingsley St., Ann Arbor, Mich. (34). 1886. **A**

Bement, A., 218 La Salle St., Chicago, Ill. (52).

Bĕndrat, Rev. Thomas Albert, Spencer, So. Dak. (52).

Benedict, Harris Miller, Instructor in Biology, University of Cincinnati, 103 West St. Clair St., Cincinnati, Ohio. (52). **F**

Benedict, James H., 704 Lords Court, New York, N. Y. (49)

Benham, J. W., 138 West 42d St., New York, N. Y. (52). **H**

*BENJAMIN, MARCUS, U. S. National Museum, Washington, D. C. (27). 1887. **C I**

*Benjamin, Rev. Raphael, M. A., Hotel St. George, Brooklyn, N. Y. (34). 1887. **E F G H**

*Benneson, Miss Cora Agnes, A. M., LL. B., 4 Mason St., Cambridge, Mass. (47). 1899. **H I**

Bennett, Charles W., Coldwater, Mich. (50). **E**

Bennett, Edward, Electrical Engineer, Amber Club, Pittsburg, Pa. (52). **D**

Bennett, Henry C., 4th Flat, 1692 Broadway, New York, N. Y. (43).

Bennett, Rev. N. E., Wilmington, Ohio. (47). **A**

*Bennett, William Z., Ph. D., Director of Chemical Laboratory, Univ. of Wooster, Wooster, Ohio. (48). 1903. **C**

Benson, Frank Sherman, 214 Columbia Heights, Brooklyn, N. Y. (49).

*Bentley, William B., Professor of Chemistry, Ohio University, Athens, Ohio. (51). 1903. **C**

Bentley, Wilson A., Jericho, Vt. (48).

Benton, John Robert, Ph. D., 132 A St., N.E., Washington, D. C. (51). **B**

*Bergey, David H., S. E. cor. 34th and Locust Sts., Philadelphia, Pa. (48). 1903. **K**

*Bergström, John Andrew, Ph. D., Associate Professor of Psychology and Pedagogy, Indiana University, Bloomington, Ind. (50). 1901. **I**

Berkeley, Wm. N., Ph. D., Box 466, San Juan, Porto Rico. (49). **C**

Berkey, Charles Peter, Ph. D., Tutor in Geology, Columbia University, New York, N. Y. (50). E

Bermann, I., M. D., The Plaza, Washington, D. C. (49). H

Bernays, Augustus Charles, M. D., 3623 Laclede Ave., St. Louis, Mo., (50). F K

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Berry, Daniel, M. D., Carmi, Ill. (41). B C E

Berry, Edgar H., care C. W. Hunt Co., West New Brighton, N. Y. (50). D

Berry, Edward W., News Building, Passaic, N. J. (50). G

Berry, John Wilson, C. E., Pittston, Pa. (47).

*Bessey, Charles Edwin, Ph. D., LL.D., Univ. of Nebraska, Lincoln, Neb. (21). 1880. G

*Bessey, Ernst A., U. S. Dep't Agriculture, Washington, D. C. (49). 1901. G

Bessey, J. Mortimer, M. D., 1814 Adams St., Toledo, Ohio. (51). K

Bethea, Solomon Hix, U. S. Attorney, Chicago Club, Chicago, Ill. (50). I

*Bethune, Rev. C. J. S., 500 Dufferin Ave., London, Ontario, Canada. (18). 1875. F

Bevier, Miss Isabel, Univ. of Illinois, Urbana, Ill. (46). C

*Beyer, Prof. Samuel W., Iowa Agricultural College, Ames, Iowa. (47). 1900. E

Beyer, T. Raymond, C. E., 119 Maplewood Ave., Germantown, Pa. (52).

*Bickmore, Prof. Albert S., Amer. Mus. Nat. History, Central Park, New York, N. Y. (17). 1880. H

Biddle, James G., 1024 Stephen Girard Building, Philadelphia, Pa. (33).

Bien, Julius, 140 Sixth Ave., New York, N. Y. (34). E H

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Bierly, Prof. H. E., State Seminary, Tallahassee, Fla. (49). H

Bierwirth, Julius C., M. D., 137 Montague St., Brooklyn, N. Y. (51). K

*Bigelow, Prof. Frank H., U. S. Weather Bureau, Washington, D. C. (36). 1888. A

Bigelow, Henry Bryant, Cohasset, Mass. (52).

*Bigelow, Maurice Alpheus, Ph. D., Instructor in Biology, Teachers' College, Columbia Univ., New York, N. Y. (51). 1903. F

*Bigelow, Robert Payne, Ph. D., Mass. Institute of Technology, Boston, Mass. (51). 1903. F

*Bigelow, S. Lawrence Ph. D., Asst. Professor of General Chemistry, University of Michigan, Ann Arbor, Mich. (51). 1903. C

Bigelow, W. D., Bureau of Chemistry, Department of Agriculture, Washington, D. C. (53). **C**

Biggins, J. Edgar, care of Gulf Refining Co., Port Arthur, Texas. (52). **C**

Biggs, Charles, 13 Astor Place, New York, N. Y. (50). **I**

Bigney, Andrew J., Professor of Biology and Geology, Moores Hill College, Moores Hill, Ind. (50). **E F**

Billings, Miss E., 279 Madison Ave., New York, N. Y. (50). **I**

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Bishop, Mrs. Josephine Hall, 2309 Washington St., San Francisco, Cal. (51). **H**

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Bissell, G. W., Professor of Mechanical Engineering, Iowa State College, Ames, Iowa. (53). **D**

Bissell, Leslie Dayton, Ph. D., Hotchkiss School, Lakeville, Conn. (50). **B**

Bitner, Henry F., Ph. D., Teacher of Natural Science, Millersville State Normal School, Millersville, Pa. (52). **B C G**

*BIXBY, MAJOR W. H., Corps of Engineers, U. S. A. (address unsettled during 1904). (34). 1892. **D**

Black, Homer V., Georgia School of Technology, Atlanta, Ga. (52). **C**

Black, N. Henry, 26 Trowbridge St., Cambridge, Mass. (50). **B**

Blackall, Clarence Howard, Architect, 1 Somerset St., Boston, Mass. (50). **D**

Blackburn, Joseph E., State Dairy and Food Commissioner, Columbus, Ohio. (50). **F I**

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Blackmore, Henry S., 206 S. 9th Ave., Mount Vernon, N. Y. (49).

Blackshear, Edward Levoisier, Principal of the Prairie View State Normal and Industrial College, Prairie View, Texas. (52). **H I**

Blain, Alexander W., Jr., 131 Elmwood Ave., Detroit, Mich. (52).

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Blair, Mrs. Eliza N., Manchester, N. H. (40).

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Blaker, Ernest, Instructor in Physics, Cornell University, Ithaca, N. Y. (51). B.
Blakeslee, Albert Francis, 12 Kirkland Place. Cambridge, Mass. (52).
Blakeslee, Olin Safford, Magnolia, Colo. (50). B D E
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Bland, John Carlisle, Engineer of Bridges, Penna. Lines West of Pittsburg, 1003 Penn Ave., Pittsburg, Pa. (51). D
Blankinship, Joseph William, Ph. D., Professor of Botany, Montana State College, Bozeman, Montana. (51). G
Blasdale, Walter Charles, Ph. D., Instructor in Chemistry, University of California, Berkeley, Cal. (50). C
Blauvelt, Harrington, Mining Engineer, Prescott, Arizona, (51). D E
*Bleile, Albert M., M. D., State University, Columbus, Ohio. (37). 1896. F
BLISH, W. G., Niles, Mich. (33). B D
Bliss, Charles B., Ph. D., Hampden, Mass. (49). H I
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Blodgett, Frederick H., Asst. Professor of Botany, Agricultural College, College Park, Md. (52). G
Bloodgood, John H., 6 W. 40th St., New York, N. Y. (49).
BLOUNT, HENRY FITCH, "The Oaks," Washington, D. C. (32). B I
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Boas, Emil L., 37 Broadway, New York, N. Y. (50). I
*Boas, Dr. Franz, Am. Mus. Nat. History, Central Park, New York, N. Y. (36). 1888. H I
*Bodine, Prof. Donaldson, Wabash College, Crawfordsville, Ind. (45). 1899. E F
*Bogert, Marston Taylor, Havemeyer Hall, Columbia Univ., New York, N. Y. (47). 1900. C
Bolce, Harold, The Franconia, Washington, D. C. (52). D F G
Bolles, Newton Alden, 1457–59 Ogden St., Denver, Colo. (50). C
*Bolley, Henry L., Agricultural College, North Dakota. (39). 1892. G
*Bolton, Thaddeus L., Ph. D., Dept. Philosophy, University of Nebraska, Lincoln, Neb. (50). 1901. H I
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Bond, R. I., M. D., Hartshorne, Ind. Ter. (50). K

Bonnet, Frederic, Jr., 2719 Russell Ave., St. Louis, Mo. (53). **I**
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Boon, John Daniel, Professor of Physics, Chemistry and Geology, John Tarleton College, Stephenville, Texas. (50). **B C E**
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Booth, Edward, Instructor in Chemistry, Univ. of California, Berkeley, Cal. (50). **C**
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Boston, L. Napoleon, M. D., 1531 S. Broad St., Philadelphia, Pa. (51). **K**
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*Bouscaren, Louis Frederic Gustav, Chief Engineer, Water Works Commission, City Hall, Cincinnati, Ohio. (50). 1901. **D**
*Bouton, Charles Leonard, Instructor in Mathematics, Harvard University, Cambridge, Mass. (50). 1901. **A**
Boutwell, John Mason, U. S. Geol. Survey, Washington, D. C. (46). **E**
*Bowditch, Charles P., 28 State St., Boston, Mass. (43). 1897. **H**
Bowditch, Miss Charlotte, Pond St., Jamaica Plain, Mass. (50). **I**
*Bowditch, Prof. H. P., Jamaica Plain, Mass. (28). 1880. **B F H**
Bowker, R. R., 28 Elm St., New York, N. Y. (43). **B**
Bowlus, E. Lingan, Professor of Biology, Monmouth College, Monmouth, Ill. (50). **F**
Bowman, Charles Henry, Professor of Mechanics and Electrical Engineering, State School of Mines, Butte, Mont. (51). **D**
Bowman, Joseph H., Resident Engineer, Vera Cruz and Pacific Ry., Apartado 21, Cordoba, Mexico. (50). **D**
Bownocker, Prof. J. A., Ohio State University, Columbus, Ohio. (48). **E**
*Bowser, Prof. E. A., Rutgers College, New Brunswick, N. J. (28). 1881.
*Boyd, James E., Ohio State Univ., Columbus, Ohio. (46). 1899. **B D**
*BOYE, MARTIN H., M. D., Coopersburg, Pa. (1). 1896. **C**
*Brace, Prof. D. B., Univ. of Nebraska, Lincoln, Neb. (48). 1900. **B**
*Bracken, Henry Martyn, M. D., 1010 Fourth St. S.E., Minneapolis, Minn. (51). 1903. **K**
BRACKENRIDGE, GEORGE W., San Antonio, Texas. (41). **I**
Brackett, Byron B., Ph. D., Clarkson School of Technology, Potsdam, N. Y. (46). **B**

*Brackett, Prof. C. F., Princeton University, Princeton, N. J. (19). 1875. B

Brackett, Frank Parkhurst, Professor of Mathematics, Pomona College, Claremont, Cal. (50). A

*Brackett, Richard N., Clemson College, S. C. (37). 1891. C E

*Bradford, Royal B., Commander, U. S. N., Navy Dept., Washington, D. C. (31). 1891. B D

BRADLEY, ARTHUR C., Newport, N. H. (43).

Bradley, Charles S., 44 Broad St., New York, N. Y. (40).

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BRADLEY, MILTON, Springfield, Mass. (44). B

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BRADLEY, STEPHEN ROWE, Nyack, New York. (51).

Bradley, Walter Parke, Ph. D., Professor of Chemistry, Wesleyan University, Middletown, Conn. (50). C

Brainerd, Erastus, Seattle, Wash. (52).

Bramwell, Geo. W., 335 Broadway, New York, N. Y. (43). D

*Branner, Prof. John C., Stanford University, Cal. (34). 1886. E F

Brasefield, Stanley Eugene, Instructor in Mathematics, Lafayette College, Easton, Pa. (50). A

*BRASHEAR, JOHN A., Allegheny, Pa. (33). 1885. A B D

Brassill, Miss Sarah Ellen, South Weymouth, Mass. (47). F G

Braunnagel, Jules L. A., M. D., P. O. Box 925, San Antonio, Texas. (50). F

*Bray, William L., Professor of Botany, Univ. of Texas, Austin, Texas. (49). 1901. G

Brayton, Sarah H., M. D., The Hereford, Evanston, Ill. (33).

Breed, Robert Stanley, Ph. D., Professor of Biology, Allegheny College, Meadville, Pa. (51). F

Brett, George P., Darien, Conn. (49).

*Brewer, Charles Edward, Professor of Chemistry, Wake Forest College, Wake Forest, N. C. (50). 1903. C

*Brewer, Prof. Wm. H., 418 Orange St., New Haven, Conn. (20). 1875. E F I

Brewster, Edwin Tenney, Instructor in Natural Sciences, Phillips Academy, Andover, Mass. (51).

Brewster, Frank H., M. E., 154 Fargo Ave., Buffalo, N. Y. (51). D

Brice, Judge Albert G., 901 Hennen Bldg., New Orleans, La. (32). H

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Briggs, Edward Cornelius, Harvard Medical School, Boston, Mass. (50). F K

*Briggs, Lyman J., U. S. Dept. Agriculture, Washington, D. C. (48). 1901. B

Briggs, Wallace Alvin, M. D., 1005 K St., Sacramento, Cal. (51). K
*Brigham, Albert Perry, Professor of Geology, Colgate Univ., Hamilton, N. Y. (41). 1900. E
Bright, Richard Riggs, Ordnance Bureau, Navy Dept., Washington, D. C. (52). D
Brill, George M., Consulting Engineer, 1134 Marquette Building, Chicago, Ill. (51). D
Bristol, John I. D., Metropolitan Building, New York, N. Y. (49).
*Bristol, Wm. H., Stevens Institute, Hoboken, N. J. (36). 1894. A B D
Brittin, Lewis H., Ansonia, Conn. (52). H
*Britton, N. L., Ph. D., N. Y. Botanical Garden, Bronx Park, New York, N. Y. (29). 1882. E G
Britton, Wilev, Special Pension Examiner, Springfield, Mo. (40). F
Brock, Luther S., M. D., Morgantown, W. Va. (51). K
Brodhead, Mark, 1733 19th St., N.W., Washington, D. C. (52).
Brodie, Paul Thomas, Professor of Mathematics, Clemson College, Clemson College, S. C. (50). A
Bronson, Dr. E. B., 10 W. 49th St., New York, N. Y. (49).
Brooks, Albert A., High School, Kansas City, Kan. (50). F G
Brooks, Alfred Hulse, U. S. Geological Survey, Washington, D. C. (52). E
Brooks, Charles, Botanical Laboratory, University of Missouri, Columbia, Mo. (53). G
Brooks, Charles Edward, Lake Roland, Md. (52). A
Brooks, Rev. Earle Amos, Waverly, W. Va. (50). F
*Brooks, Wm. Keith, M. D., Johns Hopkins Univ., Baltimore, Md. (52). 1903. K
Brooks, Prof. Wm. P., Amherst, Mass. (38). C F
*Brooks, Wm. R., D. Sc., Director Smith Observatory and Professor of Astronomy, Hobart College, Geneva, N. Y. (35). 1886. A B D
Broome, G. Wiley, M. D., 612 N. Taylor Ave., St. Louis, Mo. (51). K
Browne, Aldis B., 1419 F St. N.W., Washington, D. C. (52). I
Brown, Amos Peaslee, Ph. D., Assistant Professor of Geology and Mineralogy, Univ. of Pennsylvania, Philadelphia, Pa. (50). E
Brown, Arthur Erwin, Secy. Zoological Society of Philadelphia, 1208 Locust St., Philadelphia, Pa. (51). F
Brown, Austin H., Jr., Genl. Mgr. Trinity Copper Co., Kennett, Cal. (52). D
Browne, Charles A., Jr., Ph. D., Exper. Station, Audubon Park, New Orleans, La. (52).
Brown, Rev. Clement, 1440 M St., N.W., Washington, D. C. (52).
Brown, Edgar, Botanist in charge of Seed Laboratory, Department Agriculture, Washington, D. C. (52). G

Brown, Elisha Rhodes, President Stafford Savings and National Banks, 50 Silver St., Dover, N. H. (50). **I**

Brown, Ellis W., Supervising Principal of Public Schools, 924 24th St., N.W., Washington, D. C. (52).

Brown, George P., President The Public School Publishing Co., Bloomington, Ill. (52). **I**

Brown, Glenn V., 1302 Jefferson St., Wilmington, Del. (51). **B C E**

Brown Harold W., Delaware College, Newark, Del. (48). **B C**

Brown, John C., Instructor in Zoology, Univ. of Minnesota, Minneapolis, Minn. (52). **F K**

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*Brown, Robert, Yale University Observatory, New Haven, Conn. (11). 1874. **A**

*Brown, Mrs. Robert, Observatory Place, New Haven, Conn. (17). 1874.

Brown, Robert Marshall, 35 Eighth St., New Bedford, Mass. (48).

Brown, Samuel B., Morgantown, W. Va. (40). **E**

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*Brown, S. J., U. S. Naval Academy, Annapolis, Md. (49). 1902. **A**

Brown, W. L., 42 West 72d St., New York, N. Y. (50). **I**

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Browning, Charles Clifton, M. D., Highland, Cal. (51). **K**

*Browning, Philip Embury, Kent Chemical Laboratory, Yale University, New Haven, Conn. (46). 1903. **C**

Browning, William, M. D., 54 Lefferts Place, Brooklyn, N. Y. (53). **K**

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*Bruner, Lawrence, Professor of Entomology, Univ. of Nebraska, Lincoln, Neb. (50). 1901. **F**

BRUNTON, DAVID WILLIAM, Mining Engineer, 865 Grant Ave., Denver, Colo. (50). **D E**

*Brush, Charles F., 1003 Euclid Ave., Cleveland, Ohio. (35). 1886. **B**

*BRUSH, PROF. GEORGE J., Yale Univ., New Haven, Conn. (4). 1874. **C E**

Bryan, Joseph Hammond, 818 17th St., Washington, D. C. (52).

Bryan, Dr. Walter, Instructor in Biology, College of City of New York, 139 East 21st St., New York, N. Y. (52). F

*Bryan, Prof. William L., Indiana Univ., Bloomington, Ind. (49). 1900. H

Bryant, Miss D. L., 218 Ashe St., Greensboro, N. C. (42.) E

Bryant, Henry G., 2013 Walnut St., Philadelphia, Pa. (51). E

Bryson, Andrew, C. E., Brylgon Foundry, Reading, Pa. (51). D

Buchanan, James Isaac, Vice-President Pittsburg Trust Co., Conestoga Building, Pittsburg, Pa. (51). I

Buchholz, Carl Waldemar, Chief Engineer, Erie R.R. Co., 21 Cortlandt St., New York, N. Y. (51). D E

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*Buckhout, W. A., State College, Pa. (20). 1881. F

Buckingham, Chas. L., 38 Park Row, New York, N. Y. (28).

BUCKLEY, ERNEST ROBERTSON, Ph. D., Director Bureau of Geology and Mines and State Geologist of Missouri, Rolla, Mo. (52). E

Budington, Robert A., Mt. Hermon, Mass. (52). F K

Buffum, Burt C., Professor of Agriculture, Agricultural College, Laramie, Wyo. (42). G

Buist, John Robinson, M. D., City Board of Health, Nashville, Tenn. (50). K

Bull, Coates P., Assistant Professor Agr., Univ. of Minnesota, St. Anthony Park, Minn. (52). D G

*Bull, Prof. Storm, University of Wisconsin, Madison, Wis. (44). 1897. D

Bullard, Warren Gardner, Ph. D., Associate Professor of Mathematics, Syracuse University, Syracuse, N. Y. (50). A

Bullene, Mrs. Emma F. Jay, 1431 Court Place, Denver, Colo. (50). H

*Bumpus, H. C., Am. Mus. Nat. Hist., New York, N. Y. (49). 1900.

Bunker, Henry A., M. D., 158 Sixth Ave., Brooklyn, N. Y. (50). I

Bunn, J. F., Attorney at Law, Tiffin, Ohio, (51). B

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Burbidge, Frederick, 510 Empire State Building, Spokane, Wash. (50). D E

Burchard, Anson W., 44 Broad St., New York, N. Y. (51). D

Burdell, W. J., M. D., Lugoff, S. C. (51). K

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*Burgess, Thomas J. W., M. D., Medical Supt. Protestant Hospital for the Insane, Montreal, Can. (38). 1889. G

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Burke, Robert E., Boston Normal School, Boston, Mass. (50). **C**
Burnham, George, Jr., C. E., Burnham, Williams & Co., Baldwin Locomotive Works, 214 N. 34th St. Philadelphia, Pa. (51). **D**
*Burr, Prof. William H., Columbia University, New York, N. Y. (31). 1883.
Burrell, Herbert Leslie, M. D., 22 Newbury St., Boston, Mass. (51). **K**
Burrell, Rámon Haddock, M. D., Creighton, Neb. (51). **K**
Burrill, Thomas J., Professor of Botany, University of Illinois, Urbana, Ill. (53). **G**
Burroughs, Paul R., Allison, Iowa. (50). **C**
*Burt, Edward Angus, Ph. D., Professor of Natural History, Middlebury College, Middlebury, Vt. (50). 1901. **G**
Burton, Prof. Alfred E., Mass. Inst. Technology, Boston, Mass. (40). **E**
Burton, E. F., Demonstrator in Physics, University of Toronto, Toronto, Ontario, Canada. (53). **B**
Burton, Standish Barry, Civil and Mining Engineer, Saltillo, Coahuila, Mexico. (51). **D**
Burton, Hon. Theodore E., Cleveland, Ohio. (52). **I**
Burton-Opitz, Russell, Instructor in Physiology, Columbia University, New York, N. Y. (52). **K**
Busch, Frederick Carl, M. D., 145 Allen St., Buffalo, N. Y. (49).
Bush, John C. F., M. D., Wahoo, Neb. (51). **K**
*Bushnell, D. I., Jr., Assistant in Archæology, Peabody Museum, Cambridge, Mass. (52). 1903. **H**
*Butler, Amos W., Secretary Board of State Charities, Indianapolis, Ind. (30). 1885. **F H**
Butler, Frank Edward, President of Grayson College, Whitewright, Texas. (50). **I**
Butler, Matthew Joseph, Civil Engineer, 877 Dorchester St., Montreal, P. Q., Canada. (51). **D**
Butterfield, Arthur Dexter, Assistant Professor of Mathematics, University of Vermont, Burlington, Vt. (50). **A D**
Butterfield, Elmore E., Medical Department of Columbian University, Washington, D. C. (53). **F**
Butts, Edward Pontany, C. E., Chief Engineer, Am. Writing Paper Co., Holyoke, Mass. (51). **D**
Byrnes, Owen, Mining Engineer, P. O. Box 131, Marysville, Montana. (51). **D E**
Cabot, Samuel, Manufacturing Chemist, 70 Kilby St., Boston, Mass. (50). **C**
Cady, Hamilton Perkins, Assistant Professor of Chemistry, University of Kansas, Lawrence, Kansas. (52). **B C**

Cady, Walter G., Ph. D., Wesleyan Univ., Middletown, Conn. (49). B

*Cain, William, Professor of Mathematics, University of North Carolina, Chapel Hill, N. C. (50). 1901. A D

*Cajori, Florian, Professor of Mathematics, Colorado College, Colorado Springs, Colo. (50). 1901. A

Calder, George, 105 East 22d St., New York, N. Y. (50).

*Caldwell, Prof. George C., Cornell University, Ithaca, N. Y. (23). 1875. C

*Caldwell, Prof. Otis W., State Normal School, Charleston, Ill. (49). 1902. G

*Calkins, Gary N., Ph. D., Columbia University, New York, N. Y. (49). 1901. F

Calkins, Marshall, M. D., 14 Maple St., Springfield, Mass. (29).

*Calvert, Philip P., Ph. D., Instructor in Zoology, Biological Hall, University of Pennsylvania, Philadelphia, Pa. (50). 1903. F

*Calvert, Prof. Sidney, Univ. of Missouri, Columbia, Mo. (47). 1903. C

*Calvin, Prof. Samuel, Dir. Iowa Geol. Surv., Iowa City, Iowa. (37). 1889. E F

*Cameron, Frank K., Ph. D., Chemist, Bureau of Soils, U. S. Dept. Agriculture, Washington, D. C. (49). 1901. C

Cammann, Hermann H., 51 Liberty St., New York, N. Y. (49).

*Campbell, Douglas H., Professor of Botany, Stanford University, Cal. (34). 1888. G

Campbell, Henry Donald, Professor Geology and Biology, Washington and Lee University, Lexington, Va. (52). E F G

Campbell, Leslie Lyle, Ph. D., Westminster College, Fulton, Mo. (48).

Campbell, Marius Robison, U. S. Geological Survey, Washington, D. C. (52). E

*CAMPBELL, WILLIAM WALLACE, Director of Lick Observatory, Mt. Hamilton, Cal. (50). 1901. A

*Canby, William M., 1101 Delaware Avenue, Wilmington, Del. (17). 1878. G

*Cannon, George Lyman, Instructor in Geology, Denver High School (No. 1), Denver, Colo. (39). 1901. E

Cannon, W. A., Ph. D., Desert Botanical Laboratory, Tucson, Arizona. (52). G

Card, Fred. W., Professor of Horticulture, R. I. Coll. Agr. and Mech. Arts, Kingston, R. I. (45). G

Carey, Everett P., San Jose High School, Jan Jose, Cal. (50). B C

Cargill, Geo. W., Attorney at Law, Charleston, W. Va. (51). B D F G

*Carhart, Prof. Henry S., Univ. of Michigan, Ann Arbor, Mich. (29). 1881. B

*Carleton, M. A., U. S. Dept. Agriculture, Washington, D. C. (42). 1894. G

Carlson, Anton Julius, Ph. D., Stanford University, Cal. (52). K

Carnaghan, Edwin Dixon, Mechanical Engineer, Villa Corona, Mexico. (50). D

Carnahan, Charles T., Mining Engineer, Equitable Building, Denver, Colo. (50). D E

Carnegie, Thomas Morrison, Trustee of Carnegie Institute, Dungeness, Fernandina, Fla. (50). F

Carpenter, Ford A., U. S. Weather Bureau, San Diego, Cal. (44) B

Carpenter, Franklin R., Ph. D., Mining Expert, 1420 Josephine St. Denver, Colo. (50). D E

*Carpenter, Louis G., Agric. College, Fort Collins, Colo. (32). 1889. A B

Carr, William Kearny, 1413 K St., N.W., Washington, D. C. (52).

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*Carroll, James, M. D., 2147 F St., N.W., Washington, D. C. (50). 1903. F K

Carroll, James J., Camden, Texas. (50). F

Carrow, Flemming, M. D., University of Michigan, Ann Arbor, Mich. (51). K

Carson, Shelby Chadwick, M. D., Greensboro, Ala. (51). K

Carter, Henry C., 491 Bradford St., North Andover, Mass. (50).

Carter, James, M. D., Rawlins, Wyoming. (50). E K

CARTER, JAMES C., 277 Lexington Ave., New York, N. Y. (36).

*Carter. James Madison G., M. D., Waukegan, Ill. (39). 1895. F

Carter, John E., Knox and Coulter Sts., Germantown, Pa. (33). B H

Carter, Marion H., 504 West 143d St., New York, N. Y. (49).

*Carus, Paul, Ph. D., Editor Open Court Pub. Co., 324 Dearborn St., Chicago, Ill. (40). 1895. H

Cary, Mrs. Elizabeth M. L., 184 Delaware Ave., Buffalo, N. Y. (45). E

Case, Eckstein, Case School of Applied Science, Cleveland, Ohio. (47).

Case, Ermine Cowles, Prof. of Chemistry and Geology, State Normal School, Milwaukee, Wis. (50). B C E

*Casey, Thomas L., Major of Engineers, U. S. A., P. O. Drawer 71, St. Louis, Mo. (38). 1892. D F

*Castle, W. E., Instructor in Zoology, Harvard Univ., Cambridge, Mass. (52). 1903. F

Caswell, W. H., M. D., 201 West 55th St., New York, N. Y. (50).

Cathcart, Miss J. R., The Barnard, 71st St. and Central Park, New York, N. Y. (50).

*Catlin, Charles A., 133 Hope St., Providence, R. I. (33). 1895. **C**

Catt, George William, C. E., President, Atlantic, Gulf and Pacific Co., Park Row Building, New York, N. Y. (51). **D**

*Cattell, H. W., M. D., 3709 Spruce St., Philadelphia, Pa. (50). 1901. **K**

*CATTELL, PROF. JAMES McKEEN, Columbia Univ., New York, N. Y. (44). 1896. **B F H I**

Cerna, Dr. David, Monclova, Coahuila, Mexico. (51).

Chadbourn, Erlon R., Lewiston, Me. (29).

Chadwick, Leroy S., M. D., 1824 Euclid Ave., Cleveland, Ohio. (51).

*Chaillé, Stanford E., M. D., LL.D., Dean of Medical Department, Tulane University, New Orleans, La. (51). 1903. **K**

*Chamberlain, Charles Joseph, Dept. of Botany, University of Chicago, Chicago, Ill. (50). 1902. **G**

Chamberlain, Clark Wells, Professor of Physics, Denison University, Granville, Ohio. (53). **B**

Chamberlain, Frederic M., Bureau of Fisheries. U. S. Department of Commerce and Labor, Washington, D. C. (51). **F**

Chamberlain, Paul Mellen, Prof. of Mechanical Engineering, Lewis Institute, Chicago, Ill. (51). **D**

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*Chamberlin, T. C., Head of Dept. of Geology, Univ. of Chicago, Chicago, Ill. (21). 1877. **B E F H**

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Chambliss, Charles E., Entomologist, S. C. Exper. Sta., Clemson College, S. C. (51). **F**

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Chandler, Clarence Austin, Supt. of the Washburn Shops, Worcester Polytechnic Institute, 12 Westland St., Worcester, Mass. (52). **D**

Chandler, Elwyn Francis, Assistant Professor of Mathematics, University of North Dakota, University, N. Dak. (50). **A B**

Chandler, Richard E., Stillwater, Oklahoma. (46). **B D**

*Chandler, Seth C., 16 Craigie St., Cambridge, Mass. (29). 1882. **A**

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Channing, Walter, M. D., Brookline, Mass. (50). **I K**

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Chapman, Robert Hollister, U. S. Geological Survey, Washington, D. C. (52). **E**
Charles, Fred. L., Professor of Biology, Northern Illinois State Normal School, De Kalb, Ill. (52). **F G**
Charlton, Orlando Clarke, Professor of Biology and Geology, Kalamazoo College, Kalamazoo, Mich. (51). **E F G**
*Chase, Frederick L., Yale University Observatory, New Haven, Conn. (43). 1896. **A**
Chase, Harry Gray, Assistant Professor of Physics, Tufts College, Mass. (52). **B**
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Chase, R. Stuart, 53 Summer St., Haverhill, Mass. (18). **F**
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Cheney, Newel, Poland Center, N. Y. (52).
Cheney, Willard Colfax, Electrical Engineer, Portland, Oregon. (50). **D**
*Chester, Colby M., Rear Admiral, U. S. N., Superintendent Naval Observatory, Washington, D. C. (28). 1897. **E**
Chester, Wayland Morgan, Associate Professor of Biology, Colgate University, Hamilton, N. Y. (50). **F**
*Chickering, J. W., The Portner, Washington, D. C. (22). 1877. **G I**
Chilcott, Ellery Channing, Professor of Geology, Agricultural College, Brookings, S. D. (50). **E**
*Child, Charles Manning, Instructor in Zoology, University of Chicago, Chicago, Ill. (50). 1901. **F**
*Child, Clement D., Colgate Univ., Hamilton, N. Y. (44). 1899. **B**
Childs, James Edmund, Civil Eng., 300 W. 93d St., New York, N. Y. (51). **D**
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Chisholm, Hugh J., 813 Fifth Avenue, New York, N. Y. (50).
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*Chittenden, Frank Hurlbut, U. S. Dept. Agriculture, Washington, D. C. (48). 1901. **F**
*Chittenden, Russell H., Director of Sheffield Scientific School, Yale University, New Haven, Conn. (50). 1901. **C F**
Chittenden, Thomas A., Instructor in Mechanical Engineering, A. and M. College, W. Raleigh, N. C. (50). **D**
*Christie, James, Chief Mech. Engineer Am. Bridge Co., Pencoyd, Pa. (33). 1894. **D**

Chrystie, Wm. F., Hastings-on-Hudson, N. Y. (36).
Church, E. D., Jr., 63 Wall St., New York, N. Y. (50).
Church, Royal Tyler, Turin, N. Y. (38). D F
Churchill, William, Yale University, New Haven, Conn. (52). H
Churchill, William W., care of Westinghouse, Church, Kerr & Co., 26 Cortlandt St., New York, N. Y. (51). D
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*CILLEY, FRANK H., Mass. Inst. Technology, Boston, Mass. (49). 1901. A B D
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Clapp, Frederick Gardner, U. S. Geological Survey, Washington, D. C. (51). E
Clark, Alexander S., Westfield, N. J. (33).
Clark, Austin Hobart, 68 Perkins Hall, Cambridge, Mass. (52). F
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Clark, Friend Ebenezer, Dept. of Chemistry, Penna. State College, State College, Pa. (51). C
*Clarke, Prof. F. W., U. S. Geol. Survey, Washington, D. C. (18). 1874. C
*Clark, Gaylord Parsons, Professor of Physiology, Syracuse University, Syracuse, N. Y. (50). 1901. F K
Clark, Herbert A., 1902 P St., Lincoln, Neb. (50). B C
Clark, Howard Walton, Field Columbian Museum, Chicago, Ill. (52). F
*Clark, Hubert Lyman, Ph. D., Professor of Biology, Olivet College, Olivet, Mich. (50). 1903. F
Clark, James Albert, "The Cumberland," Washington, D. C. (52).
Clark, James Frederick, M. D., Fairfield, Iowa. (50). I K
*Clark, Prof. John E., 34 S. Park Terrace, Long Meadow, Mass. (17).
Clark, John Jesse, Manager. Text Book Dept., International Text Book Co., Scranton, Pa. (50). B D
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Clark, Miss May, Instructor in Physics, The Woman's College, Baltimore, Md. (52). B
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Clements, Joseph, M. D., Nutley, N. J. (52). K

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Clerc, Frank L., Hotel Metropole, Denver, Colo. (50). C D

Clifton, Richard S., Assistant Secretary, A. A. A. S., Lanier Heights, Washington, D. C. (49). F

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*Cockerell, T. D. A., Coburn Library, Colorado Springs, Colo. (50). 1901. F

Cockran, Hon. W. Bourke, M. C., 31 Nassau St., New York, N. Y. (50).

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Coe, Thomas Upham, M. D., Bangor, Maine. (51). K

Coffeen, Hon. H. A., Sheridan, Wyoming. (51).

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Coffin, Fletcher B., Newton, Mass. (53). C

*Coffin, Rev. Selden J., Ph. D., Lafayette College, Easton, Pa. (22). 1874. A I

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Cohen, Mendes, Civil Engineer, 825 N. Charles St., Baltimore, Md. (50). D

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Coker, Wm. Chambers, Ph. D., Associate Professor of Botany, Univ. of North Carolina, Chapel Hill, N. C. (52). G

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Cole, W. F., M. D., Waco, Texas. (51). K

Coleman, Clarence, U. S. Assistant Engineer, Duluth, Minn. (51). D H

Coleman, Walter, Prof. of Natural History, Sam Houston Normal Institute, Huntsville, Texas. (51). K

Colgate, Abner W., Morristown, N. J. (44).

Colie, Edw. M., East Orange, N. J. (30). E I

Collett, Samuel Williamson, Principal of High School, Urbana, Ohio. (50). G

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Collier, Price, Tuxedo Park, N. Y. (50).

*Collin, Prof. Alonzo, Cornell College, Mount Vernon, Iowa. (21). 1891. B C

Collin, Rev. Henry P., 58 Division St., Coldwater, Mich. (37). H

*Collingwood, Francis, Elizabeth, N. J. (36). 1888. D

Collins, Guy N., U. S. Department of Agriculture, Washington, D. C. (51). G

Collins, T. Shields, M. D., Globe, Arizona. (51). K

Colton, Geo. H., Professor of Natural Science, Hiram College, Hiram, Ohio. (51). B E

*Colvin, Verplanck, Supt. N. Y. State Adirondack Survey, Albany, N. Y. (28). 1880. E

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Comstock, Daniel F., 102 Huntington Ave., Boston, Mass. (52). B

*Comstock, Prof. Geo. C., Washburn Observatory, University of Wisconsin, Madison, Wis. (34). 1887. A

*COMSTOCK, PROF. THEO. B., Mining and Metallurgical Engineer, 534 Stinson Bldg., Los Angeles, Cal. (24). 1877. B D E

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*Conant, Prof. Levi L., Polytechnic Institute, Worcester, Mass. (39). 1892. A

Conarroe, Thomas H., M. D., 1807 Wallace St., Philadelphia, Pa. (50). F K

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Connaway, John W., Professor Veterinary Science, Missouri State Univ., Columbia, Mo. (52). F

Connelley, C. B., Supervisor Industrial Schools, Allegheny, Pa. (49). I

Connor, Leartus, M. D., President of Michigan State Medical Society, 103 Cass St., Detroit, Mich. (51). K

Conradson, Pontus H., Chief Chemist, Galena-Signal Oil Co., Franklin, Pa. (51). B C D

Constant, Frank H., Professor of Structural Engineering, University of Minnesota, Minneapolis, Minn. (51). D.

Converse, Vernon G., care of Ontario Power Co., Niagara Falls, Canada. (50). D

Conway, George M., Mechanical Engineer, 10 Belvedere, Milwaukee, Wis. (51). D

Cook, Dr. Charles D., 162 Remsen St., Brooklyn, N. Y. (25).

Cooke, George Willis, Park St., Wakefield Park, Wakefield, Mass. (47). H I

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*Cook, Melville T., De Pauw University, Greencastle, Ind. (45). 1902. G

*Cook, Orator F., U. S. Dept. of Agriculture, Washington, D. C. (40). 1892. G

*Cook, Samuel R., Case School, Cleveland, Ohio. (50). 1903. B C

*Cooley, Grace E., Ph. D., Wellesley College, Wellesley, Mass. (47). 1900. G I

*Cooley, Prof. LeRoy C., Vassar College, Poughkeepsie, N. Y. (19). 1880. B C

*Cooley, Prof. Mortimer E., University of Michigan, Ann Arbor, Mich. (33). 1885. D

*Cooley, Robert A., Zoologist and Entomologist, Montana Agr'l College and Experiment Station, Bozeman, Montana. (50). 1903. F

Cooper, Hon. Edward, 12 Washington Square, N., New York, N. Y. (49).

Cooper, Hermon Charles, Ph. D., Massachusetts Institute of Technology, Boston, Mass. (51). C

Cooper, James Campbell, Room 5, Veale Block, Topeka, Kansas. (50). C E

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Coster, William H., Chemist and Biologist to Bureau of Water, Department of Public Works, Pittsburg, Pa. (51). C

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Coulter, Samuel Monds, The Shaw School of Botany, St. Louis, Mo. (52). G

Courtis, William Munroe, 412 Hammond Bldg., Detroit, Mich. (46). E C G

Coutant, Richard Bonnet, M. D., Tarrytown, N. Y. (51). K

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Cowles, Miss Louise F., Mt. Holyoke College, South Hadley, Mass. (47). E

Cox, A. Beekman, Civil Engineer, Cherry Valley, N. Y. (50). D

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Cox, John, Professor of Experimental Physics, McGill University, Montreal, Can. (51). B

Cox, Ulysses O., Professor of Biology, State Normal School, Mankota, Minn. (50). F

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Craig, Moses, Memorial University, Mason City, Iowa. (53) G

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Crampton, C. Ward, M. D., 160 West 119th St., New York, N. Y. (53). K

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Cratty, R. I., Armstrong, Iowa. (52). G
Crawford, David Francis, Genl. Supt. Motive Power, Penna. Lines West of Pittsburg, Union Station, Pittsburg, Pa. (50). D
Crawford, John, Leon, Nicaragua, Central America. (40). E H
*Crawford, Morris B., Middletown, Conn. (30). 1889. B
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Crawley, Howard, Wyncote, Pa. (51). F
Crehore, Albert Cushing, 48 Lincoln Terrace, Yonkers, N. Y. (50). D E
Crew, Henry, Professor of Physics, Northwestern University, Evanston, Ill. (52). B
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Crockard, Frank Hearne, E. M., C. E., Asst. Mgr. Riverside Dept. National Tube Co., Lock Box 34, Wheeling, W. Va. (50). D
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*Crockett, Prof. Charles W., Rensselaer Polytechnic Institute, Troy, N. Y. (39). 1894. A D
*Crook, Alja Robinson, Ph. D., Professor of Mineralogy and Economic Geology, Northwestern University, Evanston, Ill. (47). 1902. E
Crosby, Oscar Terry, Cosmos Club, Washington, D. C. (52). C E I
Crosby, Wm. Edward, 1603 Amsterdam Ave., New York, N.Y. (52).
*Crosby, Prof. W. O., Mass. Institute Technology, Boston, Mass. (47). 1900. E
*Cross, Prof. Charles R., Mass. Inst. Technology, Boston, Mass. (29). 1880. B
Crouse, Hugh Woodward, M. D., Victoria, Texas. (50). F K
CROWELL, A. F., Woods Holl, Mass. (30). C
*Crowell, John Franklin, Bur. of Statistics, U. S. Dept. of Commerce and Labor, Washington, D. C. (50). 1901. I
*Crozier, William, Brigadier-General and Chief of Ordnance, U. S. A., War Department, Washington, D. C. (50). 1903. D
Cruikshank, Barton, D. Sc., 1813 West Genesee St., Syracuse, N. Y. (53). D
Crump, Col. M. H., Bowling Green, Ky. (29). E
Crunden, Frederick Morgan, Librarian Public Library, 3635 Laclede Ave., St. Louis, Mo. (52). I
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*Cumings, Edgar R., Asst. Professor of Geology, Indiana University, Bloomington, Ind. (48). 1901. E
*Cummings, Miss Clara E., Wellesley College, Wellesley, Mass. (47). 1899. G

Cummins, George Wyckoff, M. D., Belvidere, N. J. (50). G K

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Curtiss, Richard Sydney, Asst. Prof. of Chemistry, Union College, Schenectady, N. Y. (52). C

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Dalrymple, Rev. C. H., 27 Irving St., Cambridge, Mass. (53). **I**
Dalrymple, W. H., Prof. Vet. Science, La. State Univ. and A. & M. College, Baton Rouge, La. (50). **F K**
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Daniel, John, Professor of Physics, Vanderbilt Univ., Nashville, Tenn. (50). **B**
Danielson, A. H., Agricultural College, Fort Collins, Colo. (50). **G**
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Daugherty, Rev. Jerome, S. J., President of Georgetown Univ., Washington, D. C. (52).
Daugherty, Lewis S., Professor of Biology, State Normal School, Kirksville, Mo. (53). **F**
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*Davenport, Charles Benedict, Ph. D., Univ. of Chicago, Chicago, Ill. (46). 1898. **F**
Davenport, Eugene, Dean of the College of Agriculture, University of Illinois, Champaign, Ill. (39).
Davenport, Francis Henry, M. D., 419 Boylston St., Boston, Mass. (50). **K**
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Davidson, R. J., Agric. Exper. Station, Blacksburg, Va. (40). **C**
Davies, Arthur Ernest, Ph. D., Ohio State University, Columbus, Ohio. (53). **I**
Davies, William G., 22 E. 45th St., New York, N. Y. (49).
Davis, Abial B., 129 East Lincoln Ave., Mt. Vernon, N. Y. (44). **A**
DAVIS, ANDREW MCFARLAND, 10 Appleton St., Cambridge, Mass. (35). **H**
Davis, Bergen, Columbia University, New York, N. Y. (49). **B**
*Davis, Bradley Moore, Dept. of Botany, Univ. of Chicago, Chicago, Ill. (45). 1897. **G**
Davis, Charles F., Fort Collins, Colo. (50). **C**
Davis, Charles Gilbert, M. D., 31 Washington St., Chicago, Ill. (51). **K**
*Davis, C. H., Commander U. S. N., Navy Dept., Washington, D. C. (40). 1896.
Davis, Edward E., 47 W. Main St., Norwich, N. Y. (50).
Davis, George S., P. O. Box 724, Detroit, Mich. (50).

*Davis, Herman S., Ph. D., Director of International Latitude Station, Gaithersburg, Md. (50). 1901. A
*Davis, J. J., M. D., 1119 College Ave., Racine, Wis. (31). 1899. F G
Davis, John J., Attorney at law, Clarksburg, W. Va. (50). I
Davis, Kary Cadmus, Ph. D., Menomonee, Wis. (50). G
*Davis, Nathan Smith, M. D., LL. D., 65 Randolph St., Chicago, Ill. (51). 1903. K
Davis, N. S., Jr., 291 Huron St., Chicago, Ill. (50). F G
*Davis, Wm. Harper, Asst. in Psychology, Columbia Univ., New York, N. Y. (50). 1903. H I
*Davis, Prof. W. M., 17 Francis Ave., Cambridge, Mass. (33). 1885. B E
Davison, Alvin, Ph. D., Lafayette College, Easton, Pa. (49).
Davison, John M., 340 Oxford St., Rochester, N. Y. (38). C
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*DAVY, JOSEPH BURTT, State Agrostologist and Botanist, Department of Agriculture, Pretoria, Transvaal. (51). 1903. G
*Dawson, Percy Millard, M. D., Instructor in Physiology, Johns Hopkins Medical School, Baltimore, Md. (50). 1903. K
*DAY, WILLIAM SCOFIELD, Ph. D., 337 W. 87th St., New York, N. Y. (50). 1901. B
Dean, Edward B., Hotel Gordon, Washington, D. C. (52).
Dean, Seth, C. E., Surveyor of Mills County, Glenwood, Iowa. (34). D
Dean, Wm. H., 167 West River St., Wilkes-Barre, Pa. (50). C
Deans, John Sterling, Chief Engineer, Phoenix Bridge Co. Phoenixville, Pa. (51). D
Dearborn, George Van Ness, Ph. D., Professor of Physiology, Tufts Medical and Dental Schools, Boston, Mass. (52). K
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Delafield, Maturin L., Jr., Fieldston, Riverdale, New York, N. Y. (43). G

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Delano, Frederic A., Supt. of Motive Power, C. B. and Q. Railroad, 209 Adams St., Chicago, Ill. (50). D

Delany, Patrick Bernard, E. E., Inventor, South Orange, N. J. (50). D

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Dempster, Alexander, 5721 Stanton Ave., Pittsburg, Pa. (50). D

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*Dennis, David Worth, Professor of Biology, Earlham College, Richmond, Ind. (50). 1901. F

*Dennis, Louis Munroe, Cornell University, Ithaca, N. Y. (43). 1895. C

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*Derby, Orville A., Commissao Geologica, Sao Paulo, Brazil, South America. (39). 1890. E

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Detweiler, Andrew J., M. D., State Board of Health, Columbia, Mo. (53). K

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*Dewey, Lyster H., U. S. Dept. Agriculture, Washington, D. C. (40). 1899. F G

Dexter, E. G., Ph. D., Professor of Education and Psychology, University of Illinois, Urbana, Ill. (52). K

*Dexter, Franklin, M. D., Associate Professor of Anatomy, Harvard Medical School, Boston, Mass. (50). 1901. K

Dickerson, E. N., 141 Broadway, New York, N. Y. (49).

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Diemer, Hugo, Associate Professor of Mechanical Engineering, Univ. of Kansas, Lawrence, Kans. (49). D

*Diller, J. S., U. S. Geological Survey, Washington, D. C. (52). 1903. E

*Dimmock, George, Box 1597, Springfield, Mass. (22). 1874. F

Dimock, Mrs. Henry F., 25 East 60th St., New York, N. Y. (50).
Dimon, Miss Abigail Camp, 367 Genesee St., Utica, N. Y. (50). **F K**
Dinkey, Alva C., General Supt. Homestead Steel Works, Munhall, Pa. (50). **D**
Disbrow, William S., M. D., 151 Orchard St., Newark, N. J. (51). **K**
Dixon, Brandt B., President of Newcomb College, New Orleans, La. (52). **K**
*Dixon, Roland B., Peabody Museum, Cambridge, Mass. (46). 1901. **H**
Dixon, Samuel Gibson, M. D., Acad. Nat. Sciences, 1900 Race St., Philadelphia, Pa. (50). **F K**
Dixson, Prof. Zella Allen, Librarian University of Chicago, Chicago, Ill. (52). **I**
*Dock, George, M. D., Professor of Medicine, University of Michigan, Ann Arbor, Mich. (51). 1903. **K**
*Dodge, Charles Richards, 1336 Vermont Ave., N.W., Washington, D. C. (22). 1874.
*Dodge, Charles Wright, Univ. of Rochester, Rochester, N. Y. (39). 1898. **F**
Dodge, D. Stuart, 99 John St., New York, N. Y. (49).
Dodge, Philip T., Tribune Building, New York, N. Y. (44). **B D**
*Dodge, Richard E., Teachers' College, Columbia Univ., New York, N. Y. (49). 1901. **E I**
Dodman, Alfred C., Jr., 235 W. 108th St., New York, N. Y. (50).
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*Dolbear, Prof. A. Emerson, Tufts College, Mass. (20). 1880. **B**
Dole, Rev. Charles Fletcher, Jamaica Plain, Mass. (50). **I**
Domenech, Manuel V., Civil Engineer and Architect, Lock Box 220, Ponce, Porto Rico. (50). **D I**
Donovan, Cornelius, Assistant Engineer, U. S. Engineer Office, Custom House, New Orleans, La. (51). **D**
*Doolittle, Prof. C. L., Upper Darby, Pa. (25). 1885. **A**
*Dorsey, George A., Ph. D., Field Columbian Museum, Chicago, Ill. (39). 1892. **H**
Dorsey, Herbert Grove, Granville, Ohio. (51). **B**
*Dorsey, N. Ernest, Ph. D., Annapolis Junction, Md. (46). 1898. **B**
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Doughty, Mrs. Alla, Milford, Pa. (49).
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Douglas, James, 99 John St., New York, N. Y. (49).
Douglas, Orlando B., 20 Pleasant St., Concord, N. H. (49).

Dow, Allan Wade, District Bldg., Washington, D. C. (52). C D
Dow, Herbert H., Midland, Mich. (47). C
Dowell, Philip, Ph. D., High School, Port Richmond, N. Y. (50). F
Downing, Elliott Rowland, Ph. D., Professor of Biology, Northern State Normal School, Marquette, Mich. (51). F
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Drayer, Howard C., Manual Training School, Washington University, St. Louis, Mo. (51).
Drescher, Willibald A. E., P. O. Drawer 1033, Rochester, N. Y. (41). F
Drewett, Wm. A., M. E., 202 Rutledge St., Brooklyn, N. Y. (52). D
Dreyfus, Dr. William, 162 East 95th St., New York, N. Y. (52). C
Droop, Edward F., 1455 Bacon St., Washington, D. C. (52). I
*DROPPERS, GARRETT, President of the State University, Vermillion, S. Dak. (50). 1901. I
*Drown, Prof. Thos. M., Lehigh University, South Bethlehem, Pa. (29). 1881. C
Drummond, Isaac Wyman, Ph. D., 436 W. 22d St., New York, N. Y. (36).
*Dryer, Charles Redway, Professor of Geography, Indiana State Normal School, Terre Haute, Ind. (50). 1903. E
Duane, Russell, 911 Pine St., Philadelphia, Pa. (50). I
*Duane, William, Ph. D., Professor of Physics, State University, Boulder, Colo. (50). 1901. B
*Du Bois, PROF. AUG. J., New Haven, Conn. (30). 1882. A B D
Du Bois, Howard Weidner, 4526 Regent St., Philadelphia, Pa. (47). A
*Du Bois, Patterson, 401 So. 40th St., Philadelphia, Pa. (33). 1887. C H I
DuBois, Wm. E. B., Professor of Economics and History, Atlanta University, Atlanta, Ga. (50). I
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Dudgeon, H. R., M. D., Demonstrator of Surgery, School of Medicine, University of Texas, Galveston, Texas. (50). F K
*Dudley, Charles B., Drawer 156, Altoona, Pa. (23). 1882. B C D

Dudley, S. W., 333 York St., New Haven, Conn. (50). **A D**

*Dudley, Wm. L., Vanderbilt University, Nashville, Tenn. (28). 1881. **C**

*Dudley, Prof. Wm. R., Dept. of Systematic Botany, Stanford University, Cal. (29). 1883. **G**

Duerden, J. E., Ph. D., Professor of Biology, University of Michigan, Ann Arbor, Mich. (52). **F**

*Duggar, Benjamin Minge, Professor of Botany, Univ. of Missouri, Columbia, Mo. (45). 1900. **G**

Duke, Frank Williamson, Professor of Mathematics, Hollins Institute, Hollins, Va. (50). **A**

Dulles, Charles W., M. D., 4101 Walnut St., Philadelphia, Pa. (51). **K**

*Dumble, E. T., Consulting Geologist, Southern Pacific Co., 1306 Main St., Houston, Tex. (37). 1891. **E**

Duncan, Fred. N., Professor of Chemistry, Emory College, Oxford, Ga. (50). **C**

*Duncan, George Martin, Professor of Philosophy, Yale University, New Haven, Conn. (50). 1902. **H**

Duncanson, Henry Bruce, Professor of Biology, State Normal School, Peru, Neb. (50). **F**

Duncklee, John B., Civil Engineer, 35 Fairview Ave., South Orange, N. J. (51). **D**

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Dunham, Henry Bristol, M. D., State Sanatorium, Rutland, Mass. (51). **K**

Dunlevy, Robert Baldwin, Prof. Kansas State Normal College, Winfield, Kansas. (50). **C E**

Dunn, Gano Sillick, Vice-President and Chief Engineer, Crocker-Wheeler Company, Ampere, N. J. (50). **D**

Dunn, Ira J., M. D., 810 Peach St., Erie, Pa. (51). **K**

Dunning, Lehman H., M. D., 224 N. Meridian St., Indianapolis, Ind. (51). **K**

*Dunnington, Prof. F. P., University Station, Charlottesville, Va. (26). 1880. **C**

*Dunstan, A. St. C., Professor of Electrical Engineering, Polytechnic Institute, Auburn, Ala. (50). 1901. **B D**

*DuPont, Francis G., Montchanin, Del. (33). 1896. **A B D**

*Durand, Elias J., D. S., 402 Eddy St., Ithaca, N. Y. (41). 1899. **G**

Durand, John S., 81 Fulton St., New York, N. Y. (49).

*Durand, W. F., Ph. D., Cornell University, Ithaca, N. Y. (37). 1890. **B**

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Duvel, Joseph W. T., U. S. Dept. of Agriculture, Washington, D.C. (48). **G**

Dwight, Jonathan, Jr., M. D., 2 E. 34th St., New York, N. Y. (49).

*Dwight, Thomas, M. D., Harvard Medical School, Boston, Mass. (47). 1898. **H K**

*Dwight, Prof. William B., Vassar College, Poughkeepsie, N. Y. (30). 1882. **E F**

*Dyar, Harrison G., Ph. D., U. S. National Museum, Washington, D. C. (43). 1898.

Dyche, Lewis Lindsay, Professor of Systematic Zoology and Taxidermist, University of Kansas, Lawrence, Kans. (51). **F**

Dysterud, E., Electrical Engineer, Monterey, Mexico. (50). **D**

Eagleson, James B., M. D., 512 Burke Bldg., Seattle, Wash. (51). **K**

Earhart, Robert F., Asst. Professor of Physics, Ohio State University, Columbus, Ohio. (53). **B**

*Earle, F. S., N. Y. Botanical Garden, Bronx Park, New York. (39). 1896. **G**

Earll, Charles Isaac, M. E., 76 William St., New York, N. Y. (52). **D**

*Eastman, Charles Rochester, Museum Comp. Zoology, Cambridge, Mass. (41). 1896. **E F**

*Eastman, Prof. J. R., Andover, N. H. (26). 1879. **A**

Easton, Christopher, Deputy Superintendent, Metropolitan Hospital, Blackwell's Island, New York, N. Y. (52). **I K**

*Eastwood, Miss Alice, Curator of Herbarium, California Academy of Sciences, San Francisco, Cal. (50). 1901. **G**

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Eccles, David Charles, Northwestern Univ., Evanston, Ill. (50). **C**

*Eccles, Robert G., M. D., 191 Dean St., Brooklyn, N. Y. (31). 1894. **C F**

Eckel, Edwin C., U. S. Geological Survey, Washington, D. C. (51). **E**

Eckles, C. H., Columbia, Mo. (50). **F**

*Eddy, Prof. H. T., Univ. of Minnesota, Minneapolis, Minn. (24). 1875. **A B D**

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Edgar, Clinton G., 72 Jefferson Ave., Detroit, Mich. (46).

Edmands, Isaac Russell, Supt. Union Carbide Co., Sault Ste. Marie, Mich. (50). **C D**

Edmonds, Richard H., President and Editor, "Manufacturers' Record," Baltimore, Md. (50). **D**

Edwards, Arthur M., M. D., F. L. S., F. R. M. S., R. A. S., 423 Fourth Ave., Newark, N. J. (52). **K**

*Edwards, Prof. Charles Lincoln, Trinity College, Hartford, Conn. (49). 1900. **F**

Edwards, Col. Clarence R., U. S. A., Chief of the Bureau of Insular Affairs, War Department, Washington, D. C. (52). **I**

Edwards, Prof. John W., Iowa Wesleyan University, Mt. Pleasant Iowa. (48).

Ehrenfeld, Frederick, Ph. D., Instructor in Geology, University of Pennsylvania, Philadelphia, Pa. (50). **E**

Ehrhorn, Edward Macfarlane, County Entomologist, Santa Clara Co., Mountain View, Cal. (50). **F**

*Eichelberger, William Snyder, Ph. D., U. S. Naval Observatory, Washington, D. C. (41). 1896. **A**

*Eiesland, John, Ph. D., Professor of Mathematics, Thiel College, Greenville, Pa. (50). 1903. **A**

*Eigenmann, Carl H., Ph. D., Indiana University, Bloomington, Ind. (48). 1899. **F**

Eikenberry, William Lewis, Instructor in Botany, High School, St. Louis, Mo. (53). **G**

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Elftman, Arthur Hugo, Ph. D., Mining Engineer, 706 Globe Building, Minneapolis, Minn. (50). **E**

*Elkin, William L., Yale University Observatory, New Haven, Conn. (33). 1885. **A**

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Ellis, Alexander Casswell, Adjunct Professor Education, University of Texas, Austin, Tex. (52). **I K**

Ellis, Frederick W., M. D., Monson, Mass. (47). **B H**

Ellis, H. Bert, M. D., 243–245 Bradbury Bldg., Los Angeles, Cal. (50). **K**

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Ellis, Robert W., Hurley, S. D. (50). **E**

*Elrod, Morton John, Professor of Biology, University of Montana, Missoula, Mont. (50). 1901. **F**

Ely, Charles Russell, Professor of Natural Science, Gallaudet College, 5 Kendall Green, Washington, D. C. (52). **C**

Ely, Robert Erskine, Executive Director, League for Political Education, 23 West 44th St., New York, N. Y. (52). **I**

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*Ely, Theo. N., Chief of Motive Power, Pennsylvania R.R., Broad St. Station, Philadelphia, Pa. (29). 1886. **D**

*Emerson, Prof. Benjamin K., Box 203, Amherst, Mass. (19). 1877. **E F**

*EMERSON, C. F., Box 499, Hanover, N. H. (22). 1874. **A B**

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Emery, Albert Hamilton, Jr., 312 Main St., Stamford, Conn. (47). **D**

Emery, William O., Crawfordsville, Ind. (53). **C**

Emmerton, Frederic Augustus, 9 Bratenahl Bldg., Cleveland, Ohio. (50). **I**

Emmons, Arthur B., Newport, R. I. (50). **E**

*EMMONS, S. F., U. S. Geol. Survey, Washington, D. C. (26). 1879. **E**

Emory, Hon. Frederic, Chief of the Bureau of Foreign Commerce, State Department, Washington, D. C. (52). **I**

Enders, Howard Edwin, 1007 W. Lafayette Ave., Baltimore, Md. (50). **F G**

Engle, Horace M., Roanoke, Va. (52). **E**

Engle, Wilber Dewight, Professor of Chemistry, University of Denver, University Park, Colo. (50). **C**

*Engler, Edmund Arthur, President Worcester Polytechnic Institute, Worcester, Mass. (50). 1901. **A**

English, William Thompson, M. D., Professor of Physical Diagnosis, Western University of Pennsylvania, Pittsburg, Pa. (50). **K**

ENO, A. F., 32 Fifth Avenue, New York, N. Y. (50).

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Epper, Rev. Frowin, O. S. B., Mt. Angel, Oregon. (50). **F**

Esmond, Darwin W., Newburgh, N. Y. (50). **A I**

Esterly, Calvin Olin, Assistant in Zoology, University of California, Berkeley, Cal. (53). **F**

ESTES, DANA, Brookline, Mass. (29). **H I**

*Evans, Alexander W., M. D., 12 High St., New Haven, Conn. (45). 1903. **G**

Evans, Britton D., M. D., Medical Director of N. J. State Hospital, Morris Plains, N. J. (51). **K**

Evans, Henry Brown, 3009 Cambridge Place, Washington, D. C. (48). A

Evans, Samuel G., 211 Main St., Evansville, Ind. (39). F

Evans, Thomas, University of Cincinnati, Cincinnati, Ohio. (53). C

Evans, Walter Harrison, Ph. D., Department of Agriculture, Washington, D. C. (52). G

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Evermann, Barton Warren, Bureau of Fisheries, Department of Commerce and Labor, Washington, D. C. (52). F

Evers, Edward, M. D., 1861 N. Market St., St. Louis, Mo. (28). F H

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Fairchild, B. T., P. O. Box 1120, New York, N. Y. (36).

*Fairchild, David Grandison, U. S. Dept. Agriculture, Washington, D. C. (47). 1898. G

*Fairchild, Prof. H. L., Univ. of Rochester, Rochester, N. Y. (28). 1883. E F

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*Fargis, Rev. Geo. A., S. J., Georgetown University, Washington, D. C. (40). 1892.

Farley, Godfrey Pearson, C. E., General Manager, W. W. & F. R. R. Co., Wiscasset, Maine. (51). D

*Farlow, Dr. W. G., 24 Quincy St., Cambridge, Mass. (20). 1875. G

Farnsworth, Philo J., M. D., Clinton, Iowa. (50). K

Farquhar, Miss Helen, State Normal School, West Chester, Pa. (50). A B

*Farquhar, Henry. Census Office, Washington, D. C. (33). 1886. A B G I

Farr, Marcus S., Sc. D., Princeton Univ., Princeton, N. J. (49). E

*Farrand, Livingston, M. D., Columbia University, New York, N. Y. (50). 1902. H

Farwell, Elmer S., Steam Engineer, 507 W. 142d St., New York, N. Y. (51). A D

Farwell, Robert Benneson, C. E., 53 Monument Ave., Charlestown, Mass. (47). D
*Fassig, Oliver Lanard, Johns Hopkins University, Baltimore, Md. (46). 1899. B
Fast, Richard Ellsworth, Professor American History and Political Sciences, West Virginia University, Morgantown, W. Va. (50). I
Faught, John B., Professor of Mathematics, Northern State Normal School, Marquette, Mich. (50). A
Faull, Mrs. Annie B. Sargent, 245 McCaul St., Toronto, Canada. (52). F
Fawcett, Ezra, Mechanical and Electrical Engineer, 233 Ely St., Alliance, Ohio. (48). B D
Fawcett, William, Director, Dept. of Public Gardens and Plantations, Hope Gardens, Kingston, Jamaica, B. W. I. (53). G
Fay, L. G., Naval Office, 20 Exchange Place, New York, N. Y. (50).
Fellows, Charles S., 912 Chamber of Commerce, Minneapolis, Minn. (34). F
*Felt, Ephraim Porter, Ph. D., State Entomologist, Albany, N. Y. (44). 1899. F
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Fényes, Adalbert, M. D., P. O. Box W, Pasadena, Cal. (51). F
Ferguson, Alexander McGowen, Instructor in Botany, Univ. of Texas, Austin, Texas. (51). G
Ferguson, L. L., Optician, 155 Broadway, New York, N. Y. (52). B
Fernald, F. A., 301 W. Utica St., Buffalo, N. Y. (43). C
*Fernow, Bernhard E., Director N. Y. State College of Forestry, Cornell University, Ithaca, N. Y. (31). 1887. G I
Ferril, William C., Curator, State Historical and Natural History Society of Colorado, Denver, Colo. (50). E F G H I
Ferry, Dexter M., Jr., Seedsman, 1040 Woodward Ave., Detroit, Mich. (50). G
*Fessenden, Reginald A., care of National Electric Signalling Co., 8th and Water Sts., Washington, D. C. (47). 1899. A B
Fetterman, John Colvin, Castle Shannon, Pa. (51). E F
*Fewkes, Dr. J. Walter, Bureau of Amer. Ethnology, Washington, D. C. (48). 1900. H
Field, George Wilton, Mass. Inst. Tech., Boston, Mass. (47).
Field, W. L. W., Milton, Mass. (47). F
Finch, John Wellington, State Geologist, Victor, Colo. (50). E
Findlay, Merlin C., Professor of Biology, Park College, Parkville, Mo. (50). F

*Fink, Prof. Bruce, Professor of Botany, Iowa College, Grinnell, Iowa. (45). 1899. G

Finley, Norval Howard, 6638 Deary St., Pittsburg, Pa. (52). C

Fireman, Peter, Ph. D., Cosmos Club, Washington, D. C. (45). D

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Fischer, Louis Albert, Bureau of Standards, U. S. Department of Commerce and Labor, Washington, D. C. (47). A B C

Fish, Charles Henry, M. E., General Manager, Cocheco Mf'g Co. Dover, N. H. (51). D

*Fish, Pierre A., D. Sc., Professor of Comparative Physiology and Pharmacology, Cornell University, Ithaca, N. Y. (49). 1901. K

Fish, Walter Clark, General Elec. Co., Lynn, Mass. (50). D

Fishburne, Edward Bell, Jr., President Hoge Memorial Military Academy, Blackstone, Va. (51). D

Fisher, George E., 37 and 39 Wall St., New York, N. Y. (37).

Fisher, George Egbert, University of Pennsylvania, Philadelphia, Pa. (51).

Fisher, Henry Wright, Electrical Engineer, S. U. Cable Co., Pittsburg, Pa. (51). D

*Fisher, Irving, Ph. D., 460 Prospect St., New Haven, Conn. (50). 1901. A I

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*Fiske, Prof. Thomas S., Columbia University, New York, N. Y. 1901. (50).

Fiske, Wilbur A., Professor of Science, Richmond High School, Richmond, Ind. (51). B

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Fitz Gerald, Francis A. J., P. O. Box 118, Niagara Falls, N. Y. (50). C

Fitzpatrick, Thomas J., Estherville, Iowa. (52). G

Flanders, Charles S., Franklin, Mass. (42). E

*Flather, John J., Professor of Mechanical Engineering, University of Minnesota, Minneapolis, Minn. (44). 1896. D

Fleming, John A., 1851 Kinney Ave., E. Walnut Hills, Cincinnati, Ohio. (48).

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FLETCHER, ANDREW, 339 West 77th St., New York, N. Y. (50).

*Fletcher, James, Ph. D., Dominion Entomologist, Experimental Farm, Ottawa, Can. (31). 1883. **F**

*Fletcher, Robert, M. D., Army Medical Museum, Washington, D. C. (29). 1881. **F H**

*Fletcher, Robert, Ph. D., Director of Thayer School of Civil Engineering, Hanover, N. H. (51). 1902. **D**

Flexner, Simon, Univ. of Pennsylvania, Philadelphia, Pa. (52). **K**

Flickinger, Junius R., Sc. D., Principal of Normal School, Pres., Pa. Educational Assn., Normal School, Lock Haven, Pa. (51).

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*Flint, Austin, M. D., LL.D., Professor of Physiology, Cornell University Medical College, New York, N. Y. (50). 1901. **F K**

*Flint, James M., Surgeon U. S. N., Stoneleigh Court, Washington, D. C. (28). 1882. **F**

*Focke, Theodore M., Case School of Applied Science, Cleveland, Ohio. (44). 1903. **A B**

*Foley, Prof. Arthur Lee, Indiana University, Bloomington, Ind. (46). 1900. **B**

Folkmar, Daniel, D. S. S., care of Civil Service, Manila, P. I. (46). **H I**

Folsom, David M., Stanford University, Cal. (51). **E**

Folsom, Justus Watson, Instructor in Entomology, University of Illinois, Champaign, Ill. (53). **F**

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Foxworthy, Fred. William, Assistant in Botanical Department, Cornell Univ., Ithaca, N. Y. (52). **G**

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*Franklin, Edward Curtis, Ph. D., Stanford University, Cal. (47). 1900. **B G**

*Franklin, William S., Lehigh University, So. Bethlehem, Pa. (36). 1892. **B**

*FRAZER, DR. PERSIFOR, Drexel Building, Room 1042, Philadelphia, Pa. (24). 1879. **C E**

*Frazier, Prof. B. W., Lehigh University, So. Bethlehem, Pa. (24). 1882. **C E**

*Frear, William, State College, Pa. (33). 1886. **C**

Frederick, Charles Warnock, U. S. Naval Observatory, Washington, D. C. (50). **A B C**

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Freeman, Charles, Ph. D., Director of Clark Chemical Laboratory, Westminster College, New Wilmington, Pa. (50). **C**

Freeman, Prof. T. J. A., Loyola College, Baltimore, Md. (33). **B C**

*Freer, Prof. Paul C., Ann Arbor, Mich. (39). 1891. **C**

Freley, Jasper Warren, M. S., Professor of Physics, Wells College, Aurora, N. Y. (45). **B E**

French, E. L., Crucible Steel Co. of America, Syracuse, N.Y. (51). **C**

French, Owen B., U. S. Coast and Geodetic Survey, Washington, D. C. (52). **A D E**

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Fretz, Augustus Henry, Doylestown, Pa. (50).

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Frost, George H., C. E., Editor of "Engineering News," 220 Broadway, New York, N. Y. (50). **B D**

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*Fuller, George W., 170 Broadway, New York, N. Y. (50). 1903. **K**

*Fuller, Prof. Homer T., President Drury College, Springfield, Mo. (35). 1891. **C E**

*Fuller, Melville W., LL.D., Chief Justice U. S. Supreme Court, 1801 F St., N.W., Washington, D. C. (40). 1901. **I**

FULLER, MYRON L., Assistant Geologist, U. S. Geological Survey, Washington, D. C. (50). E

Fullmer, Edward Lawrence, Berea, Ohio. (50). F

*Fulton, Robert B., Chancellor Univ. of Mississippi, University, Miss. (21). 1887. A B

Fulton, Weston Miller, Instructor in Meteorology, University of Tennessee, Knoxville, Tenn. (50). B

Furlow, Floyd Charles, Professor of Experimental Engineering, Georgia School of Technology, Atlanta, Ga. (50). D

*Furness, Miss Caroline E., Ph. D., Vassar College, Poughkeepsie, N. Y. (47). 1899. A

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Gable, George D., Ph. D., Parsons College, Fairfield, Iowa. (40). A B

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*Gage, Mrs. Susanna Phelps, Ithaca, N. Y. (48). 1900. F

Gage-Day, Mary, M. D., 207 Wall St., Kingston-on-Hudson, N. Y. (51). K

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*Galbraith, Prof. John, School of Practical Science, Toronto, Can. (38). 1889. D

*Galloway, B. T., U. S. Dept. Agriculture, Washington, D. C. (37). 1890. G

Galloway, David Henry, M. D., Payette, Idaho (53). C

*Galloway, Thomas Walton, James Milliken Univ., Decatur, Ill. (45). 1901. F G

*Ganong, Wm. F., Professor of Botany, Smith College, Northampton, Mass. (49). 1900. G

Gantt, Henry Lawrence, Consulting Engineer, care American Locomotive Co., Schenectady, N. Y. (51). D I

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Gardiner, Charles Fox, M. D., 818 N. Cascade Ave., Colorado Springs, Colo. (51). K

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Gardiner, Rev. Frederic, Jr., Yeates School, Lancaster, Pa. (47). F H

Gardner, Rev. Corliss B., Ripley, N. Y. (29). **A B I**

Gardner, Geo. Clinton, 416 Beach St., N., Richmond Hill, New York, N. Y. (50).

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Garrison, Harriet E., M. D., 105 E. Second St., Dixon, Ill. (51). **K**

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Gary, Lester B., Instructor in Biology, Central High School, Buffalo, N. Y. (53). **F**

Gates, Fanny Cook, Instructor in Physics, Woman's College, Baltimore, Md. (50). **A B**

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Gauss, Robert, Editor "Denver Republican," Denver, Colo. (50). **I**

Gazzam, Hon. Joseph M., 611–614 Real Estate Trust Bldg., Philadelphia, Pa. (53). **A**

Geisler, Joseph F., New York Mercantile Exchange, New York, N. Y. (50).

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*Genthe, Karl Wilhelm, Ph. D., Assistant Professor of Natural History, Trinity College, Hartford, Conn. (50). 1901. **F**

George, Russell D., Professor of Geology, University of Colorado, Boulder, Colo. (53). **G**

*Germann, George B., Principal of Public School No. 130, Brooklyn, N. Y. (49). 1901. **A**

Getman, Frederick H., Johns Hopkins University, Baltimore, Md. (45). **B**

*GIBBS, PROF. WOLCOTT, Newport, R. I. (1). 1896. **B C**

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Gifford, Harold, M. D., 405 Karbach Block, Omaha, Neb. (51). **K**

*Gifford, John Clayton, New York State College of Forestry, Ithaca, N. Y. (50). 1902. **G**

Gilbert, Charles B., Supt. Public Instruction, 106 Brunswick St., Rochester, N. Y. (50). **I**

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Gilbert, Norman Everett, Professor of Physics, Dartmouth College, Hanover, N. H. (51). B

Gilchrist, John D. F., Ph. D., Government Biologist of Cape Colony, Department of Agriculture, Cape Town, South Africa. (53). F G

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Gildersleeve, Nathaniel, M. D., Assistant in Bacteriology, Laboratory of Hygiene, University of Pennsylvania, Philadelphia, Pa. (52). K

*Gill, Adam Capen, Cornell University, Ithaca, N. Y. (38). 1894. E

*Gill, Augustus Herman, Mass. Institute Technology, Boston, Mass. (44). 1896. C

*Gill, Theodore Nicholas, M. D., Cosmos Club, Washington, D. C. (17). 1874. F

*Gillette, Clarence P., Professor of Zoology, Agricultural College, Fort Collins, Colo. (50). 1901. F

Gilman, Charles Edward, Stanford University, Cal. (51). E

*Gilman, Daniel C., Johns Hopkins University, Baltimore, Md. (10). 1875. E H

*Girty, George H., Ph. D., U. S. Geol. Survey, Washington, D. C. (48). 1903. E

Glaser, C., Analytical and Consulting Chemist, 21 S. Gay St., Baltimore, Md. (49).

Glasgow, Frank A., M. D., 3894 Washington Ave., St. Louis, Mo. (53). K

Gleason, H. Allan, Asst. in Botany, Univ. of Illinois, Champaign, Ill. (50). G

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*Glenn, L. C., Ph. D., Professor of Geology, Vanderbilt University, Nashville, Tenn. (50). 1903. E

*Glenn, William, 1348 Block St., Baltimore, Md. (33). 1893. C

GLENNY, WILLIAM H., Buffalo, N. Y. (25).

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Gold, Rev. Dr. James Douglas, Covington, Ohio. (50). I

*Gold, Theodore S., West Cornwall, Conn. (4). 1887. B C

Golden, Harry E., Civil Engineer, Mann Building, Utica, N. Y. (51). D

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dsborough, John Byron, Croton-on-Hudson, N. Y. (51).
dschmidt, S. A., Ph. D., 43 Sedgwick St., Brooklyn, N. Y. (24). 1880. B C E
dsmith, Edw., 658 N. 10th St., Philadelphia, Pa. (29). 1892. B C
dthwait, James Walter, Assistant in Geology, Harvard University, Cambridge, Mass. (51). E
dthwaite, Miss Nellie Esther, Mount Holyoke College, So. Hadley, Mass. (47). C
nberg, Moses, Sc. D., 1101 E. University Ave., Ann Arbor, Mich. (51). 1903. C
ch, Frank A., Yale University, New Haven, Conn. (25). 1880. C
dale, Prof. George Lincoln, Botanic Gardens, Cambridge, Mass. (18). 1875. G
dale, Joseph Lincoln, M. D., 397 Beacon St., Boston, Mass. (50). F K
de,*John Paul, Instructor in Geography, University of Pennsylvania, Philadelphia, Pa. (52). E H I
dnow, Henry R., 95 Riverside Drive, New York, N. Y. (32). B
dspeed, Arthur Willis, Ph. D., Dept. Physics, University of Pennsylvania, Philadelphia, Pa. (47). 1898. A B
dwin, Elmer Forrest, Principal and Prof. Physics and Chemistry, Concord Branch, West Virginia State Normal School, Athens, W. Va. (50). B C
dwin, Harry M., Professor of Physical Chemistry, Mass. Institute Technology, Boston, Mass. (47). 1901. B
dwin, Rev. James, 76 Garden St., Hartford, Conn. (52). I
dyear, William H., Museum of Brooklyn Institute of Arts and Sciences, Eastern Parkway, Brooklyn, N. Y. (43). 1902. H
don, Charles Henry, Ph. D., Acting Professor of Geology, University of Washington, Seattle, Wash. (52). E
don, Clarence McC., Ph. D., Professor of Physics, Centre College, Danville, Ky. (48). A B C
don, Gustavus Ede, Scientific Director, Walker Gordon Laboratory Co., Chevy Chase, Md. (51). F
don, Leonard J., M. D., President Free Public Library, Jersey City, N. J. (52). K
don, Reginald, Newburgh, N. Y. (50).
don, Robert H., Cumberland, Md., (48). E F
, J. W., Professor Physics, Univ. of N. C., Chapel Hill, N. C. (51). B
nam, Frederic P., Associate Professor of Biology, Brown University, Providence, R. I. (53). F K
, Prof. Wm. F. M., Lafayette, Ind. (39). 1896.

Gossard, Harry Arthur, Professor of Entomology, Florida Agricultural College, Lake City, Fla. (51). **F**

Goucher, John Franklin, President of The Woman's College, Baltimore, Md. (50).

Gould, Charles Neton, Professor of Geology, University of Oklahoma, Norman, Okla. (53). **E**

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Granville, William Anthony, Ph. D., Instructor in Mathematics, Yale University, New Haven, Conn. (50). **A**

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Green, Edgar Moore, M. D., Easton, Pa. (36). **C G H**

Greene, G. K., 127 W. Market St., New Albany, Ind. (38).

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eenlach, Wallace, Deputy City Engineer, Albany, N. Y. (51). D
eenman, Jesse M., 875 Doan St., Cleveland, Ohio. (47). 1899. G
eenough, Charles Pelham, Attorney at Law, 39 Court St., Boston, Mass. (50). I
eenough, John, 31 W. 35th St., New York, N. Y. (49).
enway, James C., 667 Madison Ave., New York, N. Y. (53).
gg, William H., M. D., Port Chester, N. Y. (49).
gory, Miss Emily Ray, Ph. D., Professor of Biology, Wells College, Aurora, N. Y. (50). 1901. F
gory, Herbert E., Yale University, New Haven, Conn. (50). 1902. E
ffin, Gen. Eugene, First Vice-President, General Electric Co., 44 Broad St., New York, N. Y. (50). D
ffith, C. J., Instructor in Dairying, Agricultural College, Fort Collins, Colo. (50). F
ffith, Herbert Eugene, Professor of Chemistry, Knox College, Galesburg, Ill. (50). C
ffiths, David, Div. Agrostology, U. S. Dept. Agriculture, Washington D. C. (49). 1903. G
ggs, Robert F., Professor of Biology, Fargo College, Fargo, N. Dak. (52). G
mm, Carl Robert, Bridge and Structural Engineer, 1622 Caton Ave., Flatbush, Brooklyn, N. Y. (51). D
msley, George Perry, Secretary, Kansas Academy of Sciences, Topeka, Kansas. (51). E
ndley, Dr. Harry Sands, Associate Professor of Chemistry, University of Illinois, Urbana, Ill. (46). 1898. C
nnell, George Bird, 346 Broadway, New York, N. Y. (25). 1885. E F
swold, Clifford S., Head of Dept. of Physics, Groton School, Groton, Mass. (50). B
swold, Leon Stacy, 238 Boston St., Dorchester, Mass. (38). 1893. E
oat, Benjamin Feland, Asst. Prof. of Mathematics and Mechanics, University of Minnesota, Minneapolis, Minn. (51). 1903. A
osskopf, Ernest C., M. D., Medical Superintendent Milwaukee County Hospital, Wauwatosa, Wis. (51). K
ossman, Edward L., M. D., 413½ Kearny St., San Francisco, Cal. (53). K
osvenor, Edwin P., 414 West 118th St., New York, N. Y. (52).
osvenor, Gilbert H., "National Geographic Magazine," Corcoran Bldg., Washington, D. C. (48). E I
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Grover, Edwin Osgood, General Editor for Rand, McNally and Co., Highland Park, Ill. (52).
Grover, Frederick Orville, Professor of Botany, Oberlin College, Oberlin, Ohio. (50). G
Grower, Geo. G., Ansonia, Conn. (43). B D
Gruenberg, Benjamin C., Teacher of Biology, De Witt Clinton High School, 69 W. 88th St., New York, N. Y. (52). G
*Gruener, Hippolyte, Adelbert College, Cleveland, Ohio. (44). 1898.
Gulick, Luther Halsey, M. D., Pratt Institute, Brooklyn, N. Y. (52). K
*Gulliver, F. P., St. Marks School, Southboro, Mass. (40). 1900. E
Gummere, Henry Volkmar, Professor of Mathematics, Physics and Astronomy, Ursinus College, Collegeville, Pa. (51). A B
Gunsaülus, Rev. Frank W., President, Armour Institute, Chicago, Ill. (53).
Guth, Morris S., M. D., Supt. State Hospital for the Insane, Warren, Pa. (51). K
*Guthe, Karl E., Ph. D., Bureau of Standards, U. S. Department of Commerce and Labor, Washington, D. C. (45). 1897. B
Guthrie, Joseph E., Instructor in Zoology, Iowa State College, Ames, Iowa. (52). F
Guthrie, William Alvis, M. D., Franklin, Ky. (51). K
Guthrie, William E., M. D., Bloomington, Ill. (51). K
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Guyer, Prof. M. F., University of Cincinnati, Cincinnati, Ohio. (52). F G
Hadley, Artemus N., Box 313, Indianapolis, Ind. (51). D
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Hager, Albert Ralph, in charge Educational Exhibit, Philippines Section, La. Purchase Exposition, St. Louis, Mo. (52). B C
*Hague, Arnold, U. S. Geol. Survey, Washington, D. C. (26). 1879. E
*Hague, James D., 18 Wall St., New York, N. Y. (50). 1903. E
Hailman, James D., C. E., Shady Ave., Pittsburg, Pa. (51). A B
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e, Richard R., Beaver, Pa. (51). E
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, Bruce V., Grinnell, Iowa. (48). B
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, Edwin A., Assistant Examiner, U. S. Patent Office, Washington, D. C. (52). D
, George A., U. S. Naval Observatory, Washington, D. C. (47). 1900. A
, John Edward, Prof. of Civil Engineering, Brown University, Providence, R. I. (44). 1897. D
, Robert Thomas, U. S. Geol. Survey, Washington, D. C. (36). 1889. E
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Hoyt, Olive Sawyer, Kobe College, Kobe, Japan. (52). C

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Hubley, G. Wilbur, Electric Light Co., Louisville, Ky. (52). D

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nter, Samuel John, Associate Professor of Entomology, University of Kansas, Lawrence, Kansas. (50). 1902. F
nter, Walter David, Special Agent, U. S. Department Agriculture, Washington, D. C. (50). F
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*Kellogg, Vernon Lyman, Professor of Entomology, Stanford University, California. (50). 1901. F

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app, Alfred A., M. D., Brimfield, Peoria Co., Ill. (51). K
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app, Hon. Martin A., Chairman of the Interstate Commerce Commission, Washington, D. C. (52). 1903. I
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Purdue, Albert Homer, Professor of Geology, University of Arkansas, Fayetteville, Ark. (50). E

Puryear, Chas., Professor of Mathematics, Agric. and Mech. College, College Station, Tex. (51). A

Pusey, Charles W., M. E., President The Pusey & Jones Co., Wilmington, Del. (51). D

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Pyle, William Henry, Supt., Vandalia City Schools, Vandalia, Ill. (53). I

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Quinn, John James, Warren, Pa. (52).

Quintard, Edward A., Sewanee, Tenn., Supt. of Mines at Batopilas, Mexico. (50). E

Quiroga, Modesto, Cornell University, Ithaca, N. Y. (52).

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Randolph, Prof. L. S., Blacksburg, Va. (33). D

*Rane, Frank Wm., New Hampshire Agric. Exper. Station, Durham, N. H. (42). 1900. G

Rankin, Walter M., Professor of Invertebrate Zoology, Princeton University, Princeton, N. J. (51). F

Ransohoff, Joseph, M. D., Cincinnati, Ohio. (51). K

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Roy, Arthur J., C. E., First Assistant, Dudley Observatory, Albany, N. Y. (50). A
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Russell, A. H., Lieut. Col. U. S. A., Chief Ordnance Officer, Div. of Philippines, Manila, P. I. (38). D
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*Russell, Israel C., University of Michigan, Ann Arbor, Mich. (25). 1882. E
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Sackett, Robert L., C. E., Professor of Applied Mathematics and Astronomy, Earlham College, Richmond, Ind. (50). **A**
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Sander, Dr. Enno, St. Louis, Mo. (27). **C**
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Schaller, Waldemar T., U. S. Geological Survey, Washington, D. C. (53). E
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Scripture, Arthur M., Principal of High School, New Hartford, N. Y. (51). D
*Scripture, E. W., Yale University, New Haven, Conn. (46). 1901. H
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*Scull, Miss Sarah A., Smethport, Pa. (40). 1895. H
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h, William Benjamin, Professor of Mathematics, Tulane niversity, New Orleans, La. (50). 1901. A
h, Wm. Lincoln, Consulting Electrical and Illuminating ngineer, Concord, Mass. (47). D
h, William Sidney Tangier, Ph. D., Berkeley, Cal. (50). E
h, William T., M. D., Prof. of Physiology and Dean of Dartouth Medical School, Hanover, N. H. (51). K
k, Prof. John Conover, State Geologist, Trenton, N. J. (23). 879. E
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anner, Atreus, York, Pa. (36). 1890. H
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ashington, Dr. Henry S., Locust, N. J. (44). 1897. E

aterhouse, James Smartt, Professor of Chemistry and Natural Science, Cumberland University, Lebanon, Tenn. (50). C F G

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Weidman, Samuel, Geologist, Wisconsin State Geological and Natural History Survey, Madison, Wis. (53). **E**

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Wells, Eliab Horatio, M. D., Professor of Natural Science, Baylor Female College, Belton, Texas. (50). **F K**

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'ilcox, Guy Maurice, Professor of Physics, Armour Institute, Chicago, Ill. (53). B
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'illcox, Walter F., Ph. D., Professor of Economics, Cornell University, Ithaca, N. Y. (50). 1901. I
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'ilkins, Wm. Glyde, C. E., Westinghouse Bldg., Pittsburg, Pa. (50). D E
'ilkinson, Levi Washington, Professor of Industrial and Sugar Chemistry, Tulane University, New Orleans, La. (50). 1903. C
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'inchell, Alexander Newton, Professor of Geology and Mineralogy, State School of Mines, Butte, Mont. (50). 1903. E
'inchell, Horace V., Butte, Montana. (34). 1890. C E
'inchell, Prof. N. H., Minneapolis, Minn. (19). 1874. E H
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'ithers, W. A., Professor of Chemistry, North Carolina College of Agriculture and Mechanic Arts, West Raleigh, N. C. (33). 1891. C
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ods, Albert F., U. S. Dept. Agric., Washington, D. C. (43). 1897. **G**
ods, Carl Fred, Dartmouth College, Hanover, N. H. (53). **C**
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ods, Fred. A., M. D., Harvard Medical School, Boston, Mass. (51). 1902. **K**
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odward, R. S., Columbia University, New York, N. Y. (33). 1885. **A B D**
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odworth, William McMichael, Ph. D., 149 Brattle St., Cambridge, Mass. (44). 1898. **F**
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Hunter, Andrew Frederick.

CHATHAM.

Macfarlane, A., Gowrie Grove.

DAWSON.

Tyrrell, Joseph B.

FREDERICTON.

Riley, Isaac Woodbridge.

GUELPH.

Lochhead, William, Ontario Agricultural College.
Mills, James, Ontario Agricultural College.

HALIFAX.

Murray, Daniel A., Dalhousie College.

LINDSAY.

Cornish, George A.

LONDON.

Bethune, C. J. S., 500 Dufferin Avenue.

MONTREAL.

Burgess, Thomas J. W., Protestant Hospital for the Insane.
Butler, Matthew J., 877 Dorchester Street.
Cox, John, McGill University.
Holt, Herbert S., Montreal Light, Heat and Power Company.
Iles, George, 5 Brunswick Street.
Lampard, Henry, 102 Shuter Street.
Loeb, Leo, McGill University.
Lyman, Henry H., 74 McTavish Street.
Mills, Wesley, McGill University.
Schenck, Charles C., McGill University.
Walls, John Abbet, 1724 Notre Dame Street.

NIAGARA FALLS.

Converse, Vernon G., Ontario Power Co.

OTTAWA.

Bell, Robert, Geological Survey.
Fletcher, James, Experimental Farm.
Harmon, Miss A. Maria, 171 McLaren Street.
Klotz, Otto Julius, 437 Albert Street.
Saunders, Charles E., Experimental Farm.
Saunders, William, Experimental Farm.

Shutt, Frank T., Experimental Farm.
Whiteaves, J. F., Geological Survey.

Quebec.

Laflamme, J. C. K., Laval University.

Stanstead.

Moore, Mrs. A. H.

Toronto.

Burton, E. F., Toronto University.
Faull, Mrs. Annie B. Sargent, 245 McCaul Street.
Galbraith, John, School of Practical Science.
James, Charles C., Department of Agriculture.
Kammerer, Jacob Andrae.
Kirschmann, A., Toronto University.
McCurdy, Arthur W., 143 Bloor Street, West.
McLennan, J. C., Toronto University.
Walker, Byron Edmund.

ENGLAND.

Lampeter.

Scott, Arthur William, St. David's College.

London.

Hoover, Herbert C., care Bewick, Morring & Co., Broad Street House, New Broad Street.
Peters, Edw. T., 58 Savernake Road, N. W.
Power, Frederick B., 6 King Street, Snow Hill, E. C.
Wells, Wm. H., Jr., 2 Norfolk Street, Strand, W. C.

Oxford.

Myres, John L., Christ Church.

Rothamsted.

Warington, Robert.

FRANCE.

Menton.

Allis, Edward Phelps, Jr., Palais Carnolès.

Paris.

Loubat, Le Duc De, 47 rue Dumont d'Urville.

GERMANY.

Berlin.

Hoffmann, Friedrich, Charlottenburg, Kant Street 125.

BONN.

Miyake, Küchi, Botanisches Institut, Universitat zu Bonn.

HUNGARY.

BUDAPEST.

Krécsy, Béla, VI Bulyovsxky u. 22.

ITALY.

SAN REMO.

Kuntze, Otto, Villa Girola.

JAMAICA, B. W. I.

KINGSTON.

Fawcett, Wm., Hope Gardens.

JAPAN.

KOBE.

Hoyt, Olive Sawyer, Kobe College.

TOKYO.

Loew, Oscar.

YOKOHAMA.

Gause, Fred. Taylor.

MEXICO.

AGUASCALIENTES.

Morse, Willard S.

CEDRAL.

Alexander, Curtis.

CITY OF MEXICO.

Aguilera, José G., Ecological Institute of Mexico.
de Arozarena, Rafael M., 2 da Calle de las Estaciones.
Delafond, E., P. O. Box 2290.
Hard, James M. B., Cordobanes 16.
Sercombe, Parker H., 1a Calle San Francisco No. 8.
Smoot, Edgar Kenneth, D. F. 79 Paseo de la Reforma.

COLIMA.

Herbert, Arthur P.

CORDOBA.

Bowman, Joseph H.

Coyoacan, D. F.

Nuttall, Mrs. Zelia, Casa Alvarado.

Guadalajara.

Schiaffino, Mariano L.

Guadalupe y Calvo.

Schiertz, Ferdinand A.

Jalapa.

Gutierrez, Manuel R.

Linares.

McLimont, Andrew W.

Monclova.

Cerna, David.

Monterey.

Oysterud, E.

Pachuca.

De Landero, Carlos F.

Saltillo.

Abbott, Theodore Sperry.
Burton, Standish B.

San Nicolas del Oro.

Miller, Henry Huntington.

Sombrerete.

McMahan, Charles Hays.

Torres.

Peterson, Bertel.

Vera Cruz.

Parker, Herman B.

Villa Corona.

Carnaghan, Edwin D.

NEW ZEALAND.

Manawatee.

Frankland, Frederick W., Herston Farm, Foxton.

NICARAGUA.

Leon.

Crawford, John.

SICILY.

Catania.

Scaife, Walter B., care A. W. Elford.

SOUTH AFRICA.

Cape Town.

Gilchrist, John D., Department of Agriculture.
Lounsbury, Charles P., Department of Agriculture.
Mally, Charles William, Department of Agriculture.

Pretoria.

Davy, Joseph Burtt, Department of Agriculture.
Simpson, Charles Baird, Department of Agriculture.

TURKEY.

Harput.

Norton, Thomas H., United States Consulate.

WESTERN AFRICA.

Nigeria.

McDermott, P. A., Roman Catholic Mission, Old Calabar.

DECEASED MEMBERS.

[A list of deceased members of the Association, so far as known t the time of publishing the volume of Proceedings of the Spring-eld meeting, May, 1896, is given in that volume. At the Buffalo ieeting the Council directed the Permanent Secretary to omit he printing of the full list of deceased members in the annual vol-mes and to print only the additions to the list. Since the publica-on of the list printed in the Washington Proceedings (Vol. 52) otices have been received of the decease of the following members.]

bbot, Francis Ellingwood, 43 Larch Road, Cambridge, Mass. (50). Died October 23, 1903.
bert, S. Thayer, Metropolitan Club, Washington, D. C. (30).
llen, J. M., Hartford, Conn. (22). Died December 28, 1903.
aker, Marcus, Geological Survey, Washington, D. C. (30). Died December 12, 1903.
oies, Henry Martin, 530 Clay Avenue, Scranton, Pa. (50). Died December 12, 1903.
OLTON, H. CARRINGTON, Cosmos Club, Washington, D. C. (17). Died November 19, 1903.
ond, Fred, Cheyenne, Wyoming. (50).
lancy, Michael Albert, 1426 Corcoran St., Washington, D. C. (40).
rane, Walter, Braddock, Pa. (47). Died October 18, 1902.
ranford, J. P., Wakefield, New York, N. Y. (50). Died January 28, 1903.
ay, Fisk H., 309 Sycamore St., Lansing, Mich. (20). Died May 30, 1903.
e Peyster, Johnston Livingston, Tivoli, N. Y. (52). Died May 27, 1903.
e Schweinitz, E. A., U. S. Department of Agriculture, Washington, D. C. (36). Died ——.
ouglass, Andrew E., Am. Mus. Nat. History, New York, N.Y. (31).
ngelmann, George J., 208 Beacon Street, Boston, Mass. (25). Died November 16, 1903.
verts, Orpheus, Cincinnati, Ohio. (51). Died June 19, 1903.
well, Ervin E., Atlanta, Ga. (40). Died
aile, Thomas H., Murray Hill Hotel, New York, N. Y. (50).
oster, George Winslow, Bangor, Maine. (52.)
ibbs, J. Willard, New Haven, Conn. (33). Died April 28, 1903.
rimes, James Stanley, 1422 Wesley Ave., Evanston, Ill. (17). Died September 27, 1903.
iggins, F. W., M. D., 20 Court Street, Cortland, N. Y. (51).
sup, Henry G., Dartmouth College, Hanover, N. H. (36).
edzie, John H., 1514 Ridge Ave., Evanston, Ill. (34).

Le Grand, Leroy, Graham, Texas. (50). Died September 2
1903.

Magee, James Francis, 114 N. 17th St., Philadelphia, Pa. (51).

Marindin, Henry Louis, Coast and Geodetic Survey, Washingto
D. C. (40). Died March 25, 1904.

Moody, Lucius W., 39 Church St., New Haven, Conn. (43). Di
January 10, 1903.

Morison, George Shattuck, 49 Wall St., New York, N. Y. (5
Died July 1, 1903.

Murray, Robert Drake, M. D., Marine Hospital, Key West, Fl
(50). Died November 22, 1903.

Noyes, Theodore Richards, Kenwood, N. Y. (51). Died June
1903.

Porteous, John, 48 St. Stephen Street, Boston, Mass. (22
Died February—, 1903.

Rand, Theodore D., Radnor, Pa. (47). Died April 24, 1903.

Rhoads, Edward, Haverford College, Haverford, Pa. (47). Di
July 4, 1903.

Roberts, William C., Danville, Ky. (50).

Russell, Frank, Chloride, Arizona. (45).

Russell, John Edwards, Leicester, Mass. (47). Died October 2
1903.

SCHAFFER, CHAS., 1309 Arch Street, Philadelphia, Pa. (29
Died November 23, 1903.

Schwalbe, Carl, 1002 South Olive Street, Los Angeles, Cal. (51
Died June 14, 1903.

Sebert, Wm. F., 48 Strong Place, Brooklyn, N. Y. (41). Di
March 29, 1903.

Thurston, R. H., Cornell University, Ithaca, N. Y. (23). Di
October 25, 1903.

Van Brunt, Cornelius, 319 E. 57th St., New York, N. Y. (28
Died October 1, 1903.

Wales, Salem H., 25 East 55th Street, New York, N. Y. (36
Died December 2, 1903.

Wells, Samuel, 45 Commonwealth Avenue, Boston, Mass. (24
Died October 3, 1903.

WILCOX, WILLIAM W., 187 South Main Street, Middletown, Con
(50). Died November 10, 1903.

Walcott, Mrs. Henrietta L. T., Dedham, Mass. (29). Di
October—, 1903.

ADDRESS

BY

THE RETIRING PRESIDENT OF THE ASSOCIATION.

ADDRESS

BY

IRA REMSEN,

THE RETIRING PRESIDENT OF THE ASSOCIATION.

SCIENTIFIC INVESTIGATION AND PROGRESS.

At the weekly services of many of our churches it is cus-mary to begin with the reading of a verse or two from the riptures for the purpose, I suppose, of putting the congre-tions in the proper state of mind for the exercises which are follow. It seems to me that we may profit by this example, d accordingly I ask your attention to Article I of the Con-tution of the American Association for the Advancement of ience, which reads thus: "The objects of the Association e, by periodical and migratory meetings, to promote inter-urse between those who are cultivating science in different rts of America, to give stronger and more general impulse d more systematic direction to scientific research, and to ocure for the labors of scientific men increased facilities d a wider usefulness."

The first object mentioned, you will observe, is "to promote ercourse between those who are cultivating science in ferent parts of America; the second "to give a stronger d more general impulse and more systematic direction to entific research"; and the third "to procure for the oors of scientific men increased facilities and a wider use-ness." Those who are familiar with the history of the sociation are well aware that it has served its purposes mirably, and I am inclined to think that those who have

been in the habit of attending the meetings will agree that the object which appeals to them most strongly is the promotion of intercourse between those who are cultivating science. Given this intercourse and the other objects will be reached as a necessary consequence, for the intercourse stimulates thought, and thought leads to work, and work leads to wider usefulness.

While in 1848, when the Association was organized and the Constitution was adopted, there was a fair number of good scientific investigators in this country, it is certain that in the half century that has passed since then the number of investigators has increased very largely, and naturally the amount of scientific work done at present is very much greater than it was at that time. So great has been the increase in scientific activity during recent years that we are apt to think that by comparison scientific research is a new acquisition. In fact there appears to be an impression abroad that in the world at large scientific research is a relatively new thing, for which we of this generation and our immediate predecessors are largely responsible. Only a superficial knowledge of the history of science is necessary, however, to show that the sciences have been developed slowly, and that their beginnings are to be looked for in the very earliest times. Everything seems to point to the conclusion that men have always been engaged in efforts to learn more and more in regard to the world in which they find themselves. Sometimes they have been guided by one motive and sometimes by another, but the one great underlying motive has been the desire to get a clearer and clearer understanding of the universe. But besides this, there has been the desire to find means of increasing the comfort and happiness of the human race.

A reference to the history of chemistry will serve to show how these motives have operated side by side. One of the first great incentives for working with chemical things was the thought that it was possible to convert base metals like lead and copper into the so-called noble metals, silver and gold. Probably no idea has ever operated as strongly as this upon the minds of men to lead them to undertake chemical experi-

ents. It held control of intellectual men for centuries and was not until about a hundred years ago that it lost its hold. is very doubtful if the purely scientific question whether one rm of matter can be transformed into another would have ıd the power to control the activities of investigators for so ng a time; and it is idle to speculate upon this subject. should, however, be borne in mind that many of those who ere engaged in this work were actuated by a desire to put oney in their purses—a desire that is by no means to be ndemned without reserve, and I mention it not for the ırpose of condemning it, but to show that a motive that sometimes think of as peculiarly modern is among the dest known to man.

While the alchemists were at work upon their problems, ıother class of chemists were engaged upon problems of an ıtirely different nature. The fact that substances obtained om various natural sources and others made in the laboratory oduce effects of various kinds when taken into the system d to the thought that these substances might be useful in e treatment of disease. Then, further, it was thought that sease itself is a chemical phenomenon. These thoughts, is evident, furnish strong motives for the investigation of ıemical substances, and the science of chemistry owes much the work of those who were guided by these motives.

And so in each period as a new thought has served as the ıide we find that men have been actuated by different motives, and often one and the same worker has been under the fluence of mixed motives. Only in a few cases does it appear ıat the highest motives alone operate. We must take men as e find them, and we may be thankful that on the whole there e so many who are impelled by one motive or another or a mixture of motives to take up the work of investigating e world in which we live. Great progress is being made in nsequence and almost daily we are called upon to wonder some new and marvelous result of scientific investigation. is quite impossible to make predictions of value in regard to ıat is likely to be revealed to us by continued work, but it is fe to believe that in our efforts to discover the secrets of the

universe only a beginning has been made. No matter in what direction we may look we are aware of great unexplored territories, and even in those regions in which the greatest advances have been made it is evident that the knowledge gained is almost insignificant as compared with that which remains to be learned. But this line of thought may lead to a condition bordering on hopelessness and despondency, and surely we should avoid this condition for there is much greater cause for rejoicing than for despair. Our successors will see more and see more clearly than we do, just as we see more and see more clearly than our predecessors. It is our duty to keep the work going without being too anxious to weigh the results on an absolute scale. It must be remembered that the absolute scale is not a very sensitive instrument, and that it requires the results of generations to affect it markedly.

On an occasion of this kind it seems fair to ask the question: What does the world gain by scientific investigation? This question has often been asked and often answered, but each answer differs in some respects from the others and each may be suggestive and worth giving. The question is a profound one, and no answer that can be given would be satisfactory. In general it may be said that the results of scientific investigation fall under three heads—the material, the intellectual, and the ethical.

1. The material results are the most obvious and they naturally receive the most attention. The material wants of man are the first to receive consideration. They cannot be neglected. He must have food and clothing, the means of combating disease, the means of transportation, the means of producing heat, and a great variety of things that contribute to his bodily comfort and gratify his esthetic desires. It is not my purpose to attempt to deal with all of these and to show how science is helping to work out the problems suggested. I shall have to content myself by pointing out a few of the more important problems the solution of which depends upon the prosecution of scientific research.

First, the food problem. Whatever views one may hold in regard to that which has come to be called "race suicide,"

it is certain that the population of the world is increasing rapidly. The desirable places have been occupied. In some parts of the earth there is such a surplus of population that famines occur from time to time, and in other parts epidemics and floods relieve the embarrassment. We may fairly look forward to the time when the whole earth will be overpopulated unless the production of food becomes more scientific than it now is. Here is the field for the work of the agricultural chemist who is showing us how to increase the yield from a given area and, in case of poor and worn-out soils, how to preserve and increase their fertility. It appears that the methods of cultivating the soil are still comparatively crude, and more and more thorough investigation of the processes involved in the growth of plants is called for. Much has been learned since Liebig founded the science of Agricultural Chemistry. It was he who pointed out some of the ways by which it is possible to increase the fertility of a soil. Since the results of his investigations were given to the world the use of artificial fertilizers has become more and more general.

But it is one thing to know that artificial fertilizers are useful and it is quite another thing to get them. At first bone dust and guano were chiefly used. Then as these became dearer, phosphates and potassium salts from the mineral kingdom came into use.

At the Fifth International Congress for Applied Chemistry, held at Berlin, Germany, last June, Dr. Adolph Frank of Charlottenburg, gave an extremely interesting address on the subject of the use of the nitrogen of the atmosphere for agriculture and the industries, which bears upon the problem that we are dealing with. Plants must have nitrogen. At present this is obtained from the great beds of saltpetre found on the west coast of South America—the so-called Chili saltpetre—and also from the ammonia obtained as a by-product in the distillation of coal, especially in the manufacture of coke. The use of Chili saltpetre for agricultural purposes began about 1860. In 1900 the quantity exported was 1,453,000 tons, and its value was about $60,000,000. In the same year the world's production of ammonium sulphate was about

500,000 tons, of a value of somewhat more than $20,000,000. Of these enormous quantities about three-quarters finds application in agriculture. The use of these substances, especially of saltpetre, is increasing rapidly. At present it seems that the successful cultivation of the soil is dependent upon the use of nitrates, and the supply of nitrates is limited. Unless something is done we may look forward to the time when the earth, for lack of proper fertilizers, will not be able to produce as much as it now does, and meanwhile the demand for food is increasing. According to the most reliable estimations indeed the saltpetre beds will be exhausted in thirty or forty years. Is there a way out? Dr. Frank shows that there is. In the air there is nitrogen enough for all. The plants can make only a limited use of this directly. For the most part it must be in some form of chemical combination as, for example, a nitrate or ammonia. The conversion of atmospheric nitrogen into nitric acid would solve the problem, and this is now carried out. But Dr. Frank shows that there is another, perhaps more economical, way of getting the nitrogen into a form suitable for plant food. Calcium carbide can now be made without difficulty and is made in enormous quantities by the action of a powerful electric current upon a mixture of coal and lime. This substance has the power of absorbing nitrogen from the air, and the product thus formed appears to be capable of giving up its nitrogen to plants, or, in other words, to be a good fertilizer. It is true that this subject requires further investigation, but the results thus far obtained are full of promise. If the outcome should be what we have reason to hope, we may regard the approaching exhaustion of the saltpetre beds with equanimity. But, even without this to pin our faith to, we have the preparation of nitric acid from the nitrogen and oxygen of the air to fall back upon.

While speaking of the food problem, a few words in regard to the artificial preparation of foodstuffs. I am sorry to say that there is not much of promise to report upon in this connection. In spite of the brilliant achievements of chemists in the field of synthesis, it remains true that thus far they

ıve not been able to make, except in very small quantities, bstances that are useful as foods, and there is absolutely › prospect of this result being reached within a reasonable ne. A few years ago Berthelot told us of a dream he had ıd. This has to do with the results that, according to erthelot, are to be brought about by the advance of chemisy. The results of investigations already accomplished indite that, in the future, methods will perhaps be devised for e artificial preparation of food from the water and carnic acid so abundantly supplied by nature. Agriculture ll then become unnecessary, and the landscape will not be sfigured by crops growing in geometrical figures. Water ll be obtained from holes three or four miles deep in the rth, and this water will be above the boiling temperature, that it can be used as a source of energy. It will be obtained liquid form after it has undergone a process of natural stillation, which will free it from all impurities, including, course, disease germs. The foods prepared by artificial ethods will also be free from microbes, and there will conquently be less disease than at present. Further, the ecessity of killing animals for food will no longer exist, and ankind will become gentler and more amenable to higher fluences. There is, no doubt, much that is fascinating in this ne of thought, but whether it is worth following, depends oon the fundamental assumption. Is it at all probable that emists will ever be able to devise methods for the artificial eparation of foodstuffs? I can only say that to me it does ot appear probable in the light of the results thus far obined. I do not mean to question the probability of the timate synthesis of some of those substances that are of lue as foods. This has already been accomplished on the nall scale, but for the most part the synthetical processes nployed have involved the use of substances which themves are the products of natural processes. Thus, the fats n be made, but the substances from which they are made e generally obtained from nature and are not themselves nthetical products. Emil Fischer has, to be sure, made very all quantities of sugars of different kinds, but the task of

building up a sugar from the raw material furnished by nature—that is to say, from carbonic acid and water—presents such difficulties that it may be said to be practically impossible.

When it comes to starch, and the proteids which are the other chief constituents of foodstuffs, the difficulties are still greater. There is not a suggestion of the possibility of making starch artificially, and the same is true of the proteids. In this connection it is, however, interesting to note that Emil Fischer, after his remarkable successes in the sugar group and the uric acid group, is now advancing upon the proteids. I have heard it said that at the beginning of his career he made out a programme for his life work. This included the solution of three great problems—the determination of the constitution of uric acid, of the sugars, and of the proteids. Two of these problems have been solved. May he be equally successful with the third! Even if he should be able to make a proteid, and show what it is, the problem of the artificial preparation of foodstuffs will not be solved. Indeed, it will hardly be affected.

Although science is not likely, within periods that we may venture to think of, to do away with the necessity of cultivating the soil, it is likely to teach us how to get more out of the soil than we now do, and thus put us in a position to provide for the generations that are to follow us. And this carries with it the thought that, unless scientific investigation is kept up, these coming generations will be unprovided for.

Another way by which the food supply of the world can be increased, is by relieving tracts of land that are now used for other purposes than the cultivation of foodstuffs. The most interesting example of this kind, is that presented by the cultivation of indigo. There is a large demand for this substance, which is plainly founded upon esthetic desires of a somewhat rudimentary kind. Whatever the cause may be, the demand exists, and immense tracts of land have been, and are still, devoted to the cultivation of the indigo plant. Within the past few years scientific investigation has shown that indigo can be made in the factory from substances, the

production of which does not for the most part involve the cultivation of the soil. In 1900, according to the report of Dr. Brunck, Managing Director of the Badische Anilin- and Soda-Fabrik, the quantity of indigo produced annually in the factory "would require the cultivation of an area of more than a quarter of a million acres of land (390 square miles) in the home of the Indigo plant." Dr. Brunck adds: "The first impression which this fact may be likely to produce, is that the manufacture of indigo will cause a terrible calamity to arise in that country; but, perhaps not. If one recalls to mind that India is periodically afflicted with famine, one ought not, without further consideration, to cast aside the hope that it might be good fortune for that country if the immense areas now devoted to a crop which is subject to many vicissitudes and to violent market changes were at last to be given over to the raising of breadstuffs and other food products. "For myself," says Dr. Brunck, "I do not assume to be an impartial adviser in this matter, but, nevertheless, I venture to express my conviction that the government of India will be rendering a very great service if it should support and aid the progress, which will in any case be irresistible, of this impending change in the cultivation of that country, and would support and direct its methodical and rational execution."

The connection between scientific investigation and health is so frequently the subject of discussion that I need not dwell upon it here. The discovery that many diseases are due primarily to the action of microscopic organisms that find their way into the body and produce the changes that reveal themselves in definite symptoms is a direct consequence of the study of the phenomenon of alcoholic fermentation by Pasteur. Everything that throws light upon the nature of the action of these microscopic organisms is of value in dealing with the great problem of combating disease. It has been established in a number of cases that they cause the formation of products that act as poisons and that the diseases are due to the action of these poisons. So also, as is well known, investigation has shown that antidotes to some of these

poisons can be produced, and that by means of these antidotes the diseases can be controlled. But more important than this is the discovery of the way in which diseases are transmitted. With this knowledge it is possible to prevent the diseases. The great fact that the death rate is decreasing stands out prominently and proclaims to humanity the importance of scientific investigation. It is, however, to be noted in this connection that the decrease in the death rate compensates to some extent for the decrease in the birth rate, and that, if an increase in population is a thing to be desired, the investigations in the field of sanitary science are contributing to this result.

The development of the human race is dependent not alone upon a supply of food but upon a supply of energy in available forms. Heat and mechanical energy are absolutely essential to man. The chief source of the energy that comes into play is fuel. We are primarily dependent upon the coal supply for the continuation of the activities of man. Without this, unless something is to take its place, man is doomed. Statistics in regard to the coal supply and the rate at which it is being used up have so frequently been presented by those who have special knowledge of this subject that I need not trouble you with them now. The only object in referring to it is to show that, unless by means of scientific investigation man is taught new methods of rendering the world's store of energy available for the production of heat and of motion, the age of the human race is measured by the extent of the supply of coal and other forms of fuel. By other forms of fuel I mean, of course, wood and oil. Plainly, as the demand for land for the production of foodstuffs increases, the amount available for the production of wood must decrease, so that wood need not be taken into account for the future. In regard to oil, our knowledge is not sufficient to enable us to make predictions of any value. If one of the theories now held in regard to the source of petroleum should prove to be correct, the world would find much consolation in it. According to this theory petroleum is not likely to be exhausted, for it is constantly being formed by the action of water upon carbides that in all probability

exist in practically unlimited quantity in the interior of the earth. If this be true, then the problem of supplying energy may be reduced to one of transportation of oil. But given a supply of oil and, of course, the problem of transportation is solved.

What are the other practical sources of energy? The most important is the fall of water. This is being utilized more and more year by year since the methods of producing electric currents by means of the dynamo have been worked out. There is plainly much to be learned before the energy made available in the immediate neighborhood of the waterfall can be transported long distances economically, but advances are being made in this line, and already factories that have hitherto been dependent upon coal are making use of the energy derived from waterfalls. The more rapidly these advances take place the less will be the demand for coal, and if there were only enough waterfalls conveniently situated, there would be no difficulty in furnishing all the energy needed by man for heat or for motion.

It is a fortunate thing that, as the population of the earth increases, man's tastes become more complex. If only the simplest tastes prevailed, only the simplest occupations would be called for. But let us not lose time in idle speculations as to the way this primitive condition of things would affect man's progress. As a matter of fact his tastes are becoming more complex. Things that are not dreamed of in one generation become the necessities of the next generation. Many of these things are the direct results of scientific investigation. No end of examples will suggest themselves. Let me content myself by reference to one that has of late been the subject of much discussion. The development of the artificial dye-stuff industries is extremely instructive in many ways. The development has been the direct result of the scientific investigation of things that seemed to have little, if anything, to do with this world. Many thousands of workmen are now employed, and many millions of dollars are invested, in the manufacture of dye-stuffs that were unknown a few years ago. Here plainly the fundamental fact is the

esthetic desire of man for colors. A colorless world would be unbearable to him. Nature accustoms him to color in a great variety of combinations, and it becomes a necessity to him. And his desires increase as they are gratified. There seems to be no end to development in this line. At all events, the data at our disposal justify the conclusion that there will be a demand for every dye that combines the qualities of beauty and durability. Thousands of scientifically trained men are engaged in work in the effort to discover new dyes to meet the increasing demands. New industries are springing up and many find employment in them. As a rule the increased demand for labor caused by the establishment of these industries is not offset by the closing up of other industries. Certainly it is true that scientific investigation has created large demands for labor that could hardly find employment without these demands.

The welfare of a nation depends to a large extent upon the success of its industries. In his address as president of the British Association for the Advancement of Science given last summer Sir Norman Lockyer quotes Mr. Chamberlain thus: "I do not think it is necessary for me to say anything as to the urgency and necessity of scientific training. . . . It is not too much to say that the existence of this country, as the great commercial nation, depends upon it. . . . It depends very much upon what we are doing now, at the beginning of the twentieth century, whether at its end we shall continue to maintain our supremacy or even equality with our great commercial and manufacturing rivals." In another part of his address Sir Norman Lockyer says: "Further, I am told that the sum of £24,000,000 is less than half the amount by which Germany is yearly enriched by having improved upon our chemical industries, owing to our lack of scientific training. Many other industries have been attacked in the same way since, but taking this one instance alone, if we had spent this money fifty years ago, when the Prince Consort first called attention to our backwardness, the nation would now be much richer than it is, and would have much less to fear from competition."

But enough on the purely material side. Let us turn to the intellectual results of scientific investigation. This part of our subject might be summed up in a few words. It is so obvious that the intellectual condition of mankind is a direct result of scientific investigation that one hesitates to make the statement. The mind of man cannot carry him much in advance of his knowledge of the facts. Intellectual gains can be made only by discoveries, and discoveries can be made only by investigation. One generation differs from another in the way it looks at the world. A generation that thinks the earth is the center of the universe differs intellectually from one that has learned the true position of the earth in the solar system, and the general relations of the solar system to other similar systems that make up the universe. A generation that sees in every species of animal and plant evidence of a special creative act differs from one that has recognized the general truth of the conception of evolution. And so in every department of knowledge the great generalizations that have been reached through the persistent efforts of scientific investigators are the intellectual gains that have resulted. These great generalizations measure the intellectual wealth of mankind. They are the foundations of all profitable thought. While the generalizations of science belong to the world, not all the world takes advantage of its opportunities. Nation differs from nation intellectually as individual differs from individual. It is not, however, the possession of knowledge that makes the efficient individual and the efficient nation. It is well known that an individual may be very learned and at the same time very inefficient. The question is, what use does he make of his knowledge? When we speak of intellectual results of scientific investigation, we mean not only accumulated knowledge, but the way in which this knowledge is invested. A man who simply accumulates money and does not see to it that this money is carefully invested, is a miser, and no large results can come from his efforts. While, then, the intellectual state of a nation is measured partly by the extent to which it has taken possession of the generalizations that belong to the world, it is also measured by the

extent to which the methods by which knowledge is accumulated have been brought into requisition and have become a part of the equipment of the people of that nation. The intellectual progress of a nation depends upon the adoption of scientific methods in dealing with intellectual problems. The scientific method is applicable to all kinds of intellectual problems. We need it in every department of activity. I have sometimes wondered what the result would be if the scientific method could be employed in all the manifold problems connected with the management of a government. Questions of tariff, of finance, of international relations would be dealt with much more satisfactorily than at present if the spirit of the scientific method were breathed into those who are called upon to deal with these questions. It is plain, I think, that the higher the intellectual state of a nation the better will it deal with all the problems that present themselves. As the intellectual state is a direct result of scientific investigation, it is clear that the nation that adopts the scientific method, will in the end outrank both intellectually and industrially the nation that does not.

What are the ethical results of scientific investigation? No one can tell. There is one thought that in this connection I should like to impress upon you. The fundamental characteristic of the scientific method is honesty. In dealing with any question science asks no favors. The sole object is to learn the truth, and to be guided by the truth. Absolute accuracy, absolute fidelity, absolute honesty are the prime conditions of scientific progress. I believe that the constant use of the scientific method, must in the end leave its impress upon him who uses it. The results will not be satisfactory in all cases, but the tendency will be in the right direction. A life spent in accordance with scientific teachings would be of a high order. It would practically conform to the teachings of the highest types of religion. The motives would be different, but so far as conduct is concerned the results would be practically identical. I need not enlarge upon this subject. Unfortunately, abstract truth and knowledge of facts and of the conclusions to be drawn from them do not

at present furnish a sufficient basis for right living in the case of the great majority of mankind, and science cannot now, and I do not believe it ever can, take the place of religion in some form. When the feeling that the two are antagonistic wears away, as it is wearing away, it will no doubt be seen that one supplements the other, in so far as they have to do with the conduct of man.

What are we doing in this country to encourage scientific investigation? Not until about a quarter of a century ago can it be said that it met with any encouragement. Since then there has been a great change. Up to that time research was sporadic. Soon after it became almost epidemic. The direct cause of the change was the establishing of courses in our universities for the training of investigators somewhat upon the lines followed in the German universities. In these courses the carrying out of an investigation plays an important part. This is, in fact, the culmination of the course. At first there were not many following these courses, but it was not long before there was a demand for the products. Those who could present evidence that they had followed such courses were generally given the preference. This was especially true in the case of appointments in the colleges, some colleges even going so far as to decline to appoint any one who had not taken the degree of Doctor of Philosophy, which is the badge of the course that involves investigation. As the demand for those who had received this training increased, the number of those seeking it increased at least in the same proportion. New universities were established and old ones caught the spirit of the new movement until from one end of the country to the other centres of scientific activity are now found, and the amount of research work that is done is enormous compared with what was done twenty-five or thirty years ago. Many of those who get a taste of the work of investigation become fascinated by it and are anxious to devote their lives to it. At present, with the facilities for such work available, it seems probable that most of those who have a strong desire and the necessary industry and ability to follow it find their opportunity somewhere. There is little

danger of our losing a genius or even one with fair talent. The world is on the lookout for them. The demand for those who can do good research work is greater than the supply. To be sure the rewards are not as a rule as great as those that are likely to be won by the ablest members of some other professions and occupations, and as long as this condition of affairs continues to exist there will not be as many men of the highest intellectual order engaged in this work as we should like to see. On the other hand, when we consider the great progress that has been made during the last twenty-five years or so, we have every reason to take a cheerful view of the future. If as much progress should be made in the next quarter century, we shall, to say the least, be able to compete with the foremost nations of the world in scientific investigation. In my opinion this progress is largely dependent upon the development of our universities. Without the opportunities for training in the methods of scientific investigation there will be but few investigators. It is necessary to have a large number in order that the principle of selection may operate. In this line of work as in others, "many are called, but few are chosen."

Another fact that is working advantageously to increase the amount of scientific research done in this country is the support given by the Government in its different scientific bureaus. The Geological Survey, the Department of Agriculture, the Coast and Geodetic Survey, the National Bureau of Standards, and other departments are carrying on a large amount of excellent scientific work, and thus helping most efficiently to spread the scientific spirit throughout the land.

Finally, two exceedingly interesting experiments in the way of encouraging scientific investigation are now attracting the attention of the world. I mean, of course, the Carnegie Institution, with its endowment of $10,000,000, and the Rockefeller Institute, devoted to investigations in the field of medicine, which will no doubt be adequately endowed. It is too early to express an opinion in regard to the influence of these great foundations upon the progress of scientific investigation. As both will make possible the carrying out of

ny investigations that would otherwise probably not be
ried out, the chances of achieving valuable results will be
reased. The danger is that those who are responsible for
management of the funds will be disappointed that the re-
ts are not at once of a striking character, and that they will
tempted to change the method of applying the money be-
e those who are using it have had a fair chance. But we
o are on the outside know little of the plans of those who
inside. All signs indicate that they are making an earnest
ort to solve an exceedingly difficult problem, and all who
ve the opportunity should do everything in their power
aid them.

In the changes which have been brought about in the con-
ion of science in this country since 1848, it is safe to say
at this Association has either directly or indirectly played
eading part. It is certain that for the labors of scientific
n increased facilities and a wider usefulness have been
ocured.

SECTION A.

Mathematics and Astronomy.

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ADDRESS

BY

GEORGE BRUCE HALSTED,

VICE-PRESIDENT AND CHAIRMAN OF SECTION A FOR 1903.

THE MESSAGE OF NON-EUCLIDEAN GEOMETRY.

I. MATHEMATICS AND ITS HISTORY.

The great Sylvester once told me that he and Kronecker, in attempting a definition of mathematics, got so far as to agree that it is poetry.

But the history of this poesy is itself poetry, and the creation of non-Euclidean geometry gives new vantage-ground from which to illuminate the whole subject, from before the time when Homer describes Proteus as finger-fitting-by-fives, or counting, his seals, past the epoch when Lagrange, confronted with the guillotine and asked how he can make himself useful in the new world, answers simply, "I will teach arithmetic."

Who has not wished to be a magician like the mighty Merlin, or Dr. Dee, who wrote a preface for the first English translation of Euclid, made by Henricus Billingsley, afterward, Aladdin-like, Sir Henry Billingsley, Lord Mayor of London?

Was not Harriot, whose devices in Algebra our school-boys now use, one of the three paid magi of the Earl of Northumberland? Do not our every-day numerals stand for Brahmin and Mohammedan, coming first into Europe from the land of the sacred Ganges, around by the way of the Pyramids and the Moorish Alhambra?

The appearance of courses on the history of mathematics in all our foremost universities is a fortunate and promising sign of the times. I had the honor of being the first to give such a course in America, at Princeton, in 1881.

2. GEOMETRY AND ITS FOUNDERS.

But something especially fascinating, pure, divine, seems to pertain to Geometry.

When asked how God occupies himself, Plato answered, "He geometrizes continually."

It is a difficult, though highly interesting, undertaking to investigate the vestiges of primitive geometry. Geometric figures and designs appear in connection with the primitive arts: for example, the making of pottery. Arts long precede anything properly to be called science. The first creations by mankind are instruments for life, though it is surprising how immediately decoration appears; witness the sketches from life of mammoth and mastodon and horses by prehistoric man. But, in a sense, even the practical arts must be preceded by theoretical creative acts of the human mind. Man is from the first a creative thinker. Perhaps even some of our present theoretical presentation of the universe is due to creative mental acts of our pre-human ancestors. For example, that we inevitably view the world as consisting of distinct individuals, separate, distinct things, is a pre-human contribution to our working theory and representation of the universe. It is conscious science, as a potential presentation and explanation of everything, which comes so late.

Rude instruments were made for astronomy.

The creative imagination which put the bears and bulls and crabs and lions and scorpions into the random-lying stars made figures which occur in the Book of Job, more ancient than Genesis itself.

The daring astrologer, whose predictions foretold eclipses, saw no reason why his constructions should not equally fit human life. He chose to create a causal relation between the geometric configurations of the planets and the destinies

f individuals. This was the way of science, where thought recedes and helps to make fact. No description or observaion is possible without a precedent theory, which stays and ticks until some mind creates another to fight it, and perhaps o overshadow it.

That legend of the origin of geometry which attributes it o the necessity of refixing land-boundaries in Egypt, where ll were annually obliterated by the Nile overflow, is a toogenious hypothesis, made temporarily to serve for history. ome practical devices for measurement arose in Egypt, here periodic fertility fostered a consecutive occupancy, hose records, according to Flinders Petrie, we have for more han nine thousand years.

But in the Papyrus of the Rhind, measurements of volume ome before those for surface.

Geometry as a self-conscious science waits for Thales and ythagoras.

We find in Herodotus that Thales predicted an eclipse emorable as happening during a battle between the Lydians nd Medes. The date was given by Baily as B. C. 610.

So we know about when Geometry, we may say when cience, began; for though primarily geometer, Thales taught he sphericity of the earth, was acquainted with the attracting ower of magnetism, and noticed the excitation of electricity a amber by friction.

A greater than he, Pythagoras, was born B. C. 590 at Samos, raveled also into Egypt and the East, penetrating even into ndia. Returning in the time of the last Tarquin, and finding amos under the dominion of the tyrant Polycrates, he went s a voluntary exile to Italy, settled at Croton (as Ovid menons), and there created and taught new and sublimer ypotheses for our universe. The most diversely demontrated and frequently applied theorem of geometry bears is name. The first solution of a problem in that most subtle nd final of ways, by proving it impossible, is due to him; is solution of the problem to find a common submultiple of he hypothenuse and side of an isosceles right triangle, an chievement whereby he created incommensurability.

It is noteworthy that this making of incommensurables is confused by even the most respectable of the historians of mathematics with the creation of irrational numbers. But in the antique world there were no such numbers as the square root of two or the square root of three. Such numbers cannot be discovered, and it was centuries before they were created. The Greeks had only rational numbers.

3. EUCLID.

Under the Horseshoe Falls at Niagara press on beyond the guide; risk life for the magnificent sensation of a waterspout, a cloud burst, an avalanche, a tumbling cathedral of water-blocks! It *must* end in an instant, this extravagant down-pour of whole wealths of water. Then out; and look away down the glorious canyon, and read in that graven history how this momentary riotous chaos has been just so, precisely the same, for centuries, for ages, for thousands of years.

In the History of Science a like antithesis of sensations is given by Euclid's geometry.

In the flood of new discovery and rich advance recorded in books whose mere names would fill volumes, we ask ourselves how any one thing can be permanent? Yet, looking back, we see this Euclid not only cutting his resistless way through the rock of the two thousand years that make the history of the intellectual world, but, what is still more astounding, we find that the profoundest advance of the last two centuries has only served to emphasize the consciousness of Euclid's perfection.

Says Lyman Abbott, if you want an infallible book go not to the Bible but to Euclid.

In "The Wonderful Century," Alfred Russel Wallace says, speaking of all time before the seventeenth century: "Then going backward, we can find nothing of the first rank except Euclid's wonderful system of geometry, perhaps the most remarkable product of the earliest civilizations."

Says Professor Alfred Baker, of the University of Toronto: "Of the perfection of Euclid (B. C. 290) as a scientific treatise,

f the marvel that such a work could have been produced wo thousand years ago, I shall not here delay to speak. I ontent myself with making the claim that, as a historical udy, Euclid is, perhaps, the most valuable of those that re taken up in our educational institutions."

At its very birth this typical product of the Greek genius ssumed sway over the pure sciences. In its first efflorescence, hrough the splendid days of Theon and Hypatia, fanatics ould not murder it as they did Hypatia, nor later could that ismal flood, the dark ages, drown it. Like the phœnix of s native Egypt it rises anew with the new birth of culture. n Anglo-Saxon, Adelhard of Bath, finds it clothed in Arabic estments in the Moorish land of the Alhambra.

In 1120, Adelhard, disguised as a Mohammedan student, ent to Cordova, obtained a Moorish copy of Euclid's *Ele- ents*, and made a translation from the Arabic into Latin.

The first translation into English (1570) was made by Henricus Billingsley," afterward Sir Henry Billingsley, ord Mayor of London, 1591. And up to this very year, hroughout the vast system of examinations carried on by he British government, by Oxford, and by Cambridge, to be ccepted, no proof of a theorem in geometry should infringe uclid's sequence of propositions. For two millenniums his xioms remained undoubted.

4. THE NEW IDEA.

The break from Euclid's charmed circle came not at any f the traditional centers of the world's thought, but on the ircumference of civilization, at Maros-Vásárhely and Temes- ár, and again at Kazan on the Volga, center of the old atar kingdom; and it came as the creation of a wilful, wild lagyar boy of 21, and an insubordinate young Russian, who, poor widow's son from Nijni-Novgorod, enters as a charity- udent the new university of Kazan.

The new idea is to deny one of Euclid's axioms and to eplace it by its contradictory. There results, instead of haos, a beautiful, a perfect, a marvellous new geometry.

5. HOW THE NEW DIFFERS FROM THE OLD.

Euclid had based his geometry on certain axioms or postulates which had in all lands and languages been systematically used in treatises on geometry, so that there was in all the world but one geometry. The most celebrated of these axioms was the so-called parallel-postulate, which, in a form due to Ludlam, is simply this: "Two straight lines which cut one another cannot *both* be parallel to the same straight line."

Now this same Magyar, John Bolyai, and this Russian, Lobachevski, made a geometry based not on this axiom or postulate, but on its direct contradiction. Wonderful to say, this new geometry, founded on the flat contradiction of what had been forever accepted as axiomatic, turned out to be perfectly logical, true, self-consistent, and of marvellous beauty. In it many of the good old theorems of Euclid and our own college days are superseded in a surprising way. Through any point outside any given straight line can be drawn an infinity of straight lines in the same plane with the given line, but which nowhere would meet it, however far both were produced.

6. A CLUSTER OF PARADOXES.

In Euclid, Book I, Proposition 32, is that the sum of the angles in every rectilineal triangle is *just exactly* two right angles. In this new or non-Euclidean geometry, on the contrary, the sum of the angles in every rectilineal triangle is *less* than two right angles.

In the Euclidean geometry parallels *never* approach. In this non-Euclidean geometry parallels *continually* approach.

In the Euclidean geometry all points equidistant from a straight line are on a *straight* line. In this non-Euclidean geometry all points equidistant from a straight line are on a *curve* called the equidistantial.

In the Euclidean geometry the limit approached by a circumference as the radius increases is a *straight* line. In the non-Euclidean geometry this is a *curve* called the oricycle.

'hus the method of Kempe's book "How to draw a straight ine," would here draw not a straight line, but a curve.

In the Euclidean geometry, if three angles of a quadrilateral re right, then the fourth is *right*, and we have a rectangle. n this non-Euclidean geometry, if three angles of a quadri-ateral are right, then the fourth is *acute*, and we never can ave any rectangle.

In the Euclidean geometry two perpendiculars to a line emain *equidistant*. In this non-Euclidean geometry two erpendiculars to a line *spread away from each other* as they o out; their points two inches from the line are farther apart han their points one inch from the line.

In the Euclidean geometry every three points are either on *straight* line or a *circle*. In this non-Euclidean geometry here are triplets of points which are neither *costraight* nor *oncyclic*. Thus three points each one inch above a straight ine are neither on a straight line nor a circle.

7. MISTAKE OF THE INEXPERT.

These seeming paradoxes could be multiplied indefinitely, nd they form striking examples of this new geometry. They eem so bizarre, that the first impression produced on the nexpert is that the traditional geometry could easily be roved, as against this rival, by careful experiments. Into his error have fallen Professors Andrew W. Phillips and rving Fisher, of Yale University. In their Elements of eometry, 1898, page 23, they say: "Lobachevski proved hat we can never get rid of the parallel axiom without assum-ng the space in which we live to be very different from what e know it to be through experience. Lobachevski tried to nagine a different sort of universe in which the parallel xiom would not be true. This imaginary kind of space is alled *non-Euclidean* space, whereas the space in which we eally live is called *Euclidean*, because Euclid (about 300 . C.) first wrote a systematic geometry of our space."

Now, strangely enough, no one, not even the Yale Pro-essors, can ever prove this naïve assertion. If any one of

the possible geometries of uniform space could ever be proved to be the system actual in our external physical world, it certainly could not be Euclid's.

Experience can never give, for instance, such absolutely exact metric results as precisely, perfectly two right angles for the angle sum of a triangle. As Dr. E. W. Hobson says: "It is a very significant fact that the operation of counting, in connection with which numbers, integral and fractional, have their origin, is the one and only absolutely exact operation of a mathematical character which we are able to undertake upon the objects which we perceive. On the other hand, all operations of the nature of measurement which we can perform in connection with the objects of perception contain an essential element of inexactness. The theory of exact measurement in the domain of the ideal objects of abstract geometry is not immediately derivable from intuition."

8. THE ARTIFICIALLY CREATED COMPONENT IN SCIENCE.

In connecting a geometry with experience there is involved a process which we find in the theoretical handling of any empirical data, and which, therefore, should be familiarly intelligible to any scientist.

The results of any observations are always valid only within definite limits of exactitude and under particular conditions. When we set up the axioms, we put in place of these results statements of absolute precision and generality. In this idealization of the empirical data our addition is at first only restricted in its arbitrariness in so much as it must seem to approximate, must apparently fit, the supposed facts of experience, and, on the other hand, must introduce no logical contradiction. Thus our actual space to-day may very well be the space of Lobachevski or Bolyai.

If anything could be proved or disproved about the nature of space or geometry by experiments, by laboratory methods, then our space could be proved to be the space of Bolyai by inexact measurements, the only kind which will ever be at our disposal. In this way it might be known to be *non*-Euclidean. It never can be known to be Euclidean.

9. DARWINISM AND GEOMETRY.

The doctrine of evolution as commonly expounded postu-
ates a world independent of man, and teaches the production
f man from lower forms of life by wholly natural and uncon-
cious causes. In this statement of the world of evolution
here is need of some rudimentary approximative practical
eometry.

The mighty examiner is death. The puppy, though born
lind, must still be able to superimpose his mouth upon the
ource of his nourishment. The little chick must be able,
esponding to the stimulus of a small bright object, to bring
is beak into contact with the object so as to grasp and then
wallow it. The springing goat that too greatly misjudges
n abyss does not survive and thus is not the fittest.

So, too, with man. We are taught that his ideas must in
ome way and to some degree of approximation correspond
o this independent world, or death passes upon him an ad-
erse judgment.

But it is of the very essence of the doctrine of evolution that
an's knowledge of this independent world, having come by
radual betterment, trial, experiment, adaptation, and
hrough imperfect instruments, for example the eye, cannot
e metrically exact.

If two natural hard objects, susceptible of high polish, be
round together, their surfaces in contact may be so smoothed
s to fit closely together and slide one on the other without
eparating. If now a third surface be ground alternately
gainst each of these two smooth surfaces until it accurately
ts both, then we say that each of the three surfaces is approxi-
ately plane. If one such plane surface cut through another,
e say the common boundary or line where they cross is
pproximately a straight line. If three approximately plane
urfaces on objects cut through a fourth, in general they make
figure we may call an approximate triangle. Such triangles
ary greatly in shape. But no matter what the shape, if
e cut off the six ends of any two such and place them side
y side on a plane with their vertices at the same point, the

six are found, with a high degree of approximation, just to fill up the plane about the point. Thus the six angles of any two approximate triangles are found to be together approximately four right angles.

Now does the exactness of this approximation depend only on the straightness of the sides of the original two triangles, or also upon the size of these triangles?

If we know with absolute certitude, as the Yale professors imagine, that the size of the triangles has nothing to do with it, then we know something that we have no right to know, according to the doctrine of evolution; something impossible for us ever to have learned evolutionally.

10. THE NEW EPOCH.

Yet before the epoch-making ideas of Lobachevski and John Bolyai every one made this mistake, everyone supposed we were perfectly sure that the angle-sum of an actual approximate triangle approached two right angles with an exactness dependent only on the straightness of the sides, and not at all on the size of the triangle.

11. THE SLIPS OF PHILOSOPHY.

The Scotch philosophy accounted for this absolute metrically exact knowledge by teaching that there are in the human mind certain synthetic theorems, called intuitions, supernaturally inserted there. Dr. McCosh elaborated this doctrine in a big book entitled "The Intuitions of the Mind Inductively Investigated." One of these supernatural intuitions was Euclid's parallel-postulate! *Voila!*

"Yet," to quote a sentence from Wenley's criticism in "Science," of McCosh's disciple Ormond, "we may well doubt whether a thinker, standing with one foot firmly planted on the Rock of Ages and the other pointing heavenward, has struck the attitude most conducive to progress."

Kant, supposing that we knew Euclid's geometry and Aristotle's logic to be true absolutely and necessarily, accounted for the paradox by teaching that this seemingly

iiversal synthetic knowledge was in reality particular, being
art of the apparatus of the human mind itself.

But now the very foundations are cut away from under the
antian system of philosophy by this new geometry which
in simple and perfect harmony with experience, with experi-
ent, with the properties of the solid bodies and the motions
bout us. Thus this new geometry has given explanation of
hat in the old geometry was accepted without explanation.

12. WHAT GEOMETRY IS.

At last we really know what geometry is. Geometry is
ie science created to give understanding and mastery of
ie external relations of things; to make easy the explana-
on and description of such relations and the transmission of
iis mastery. Geometry is the most perfect of the sciences.
precedes experiment and is safe above all experimentation.

The pure idea of a plane is something we have made, and
y aid of which we see surfaces as perfectly plane, over-riding
nperfections and variations, which themselves we can see
nly by help of our self-created precedent idea. Just so the
raight line is wholly a creation of our own.

13. ARE THERE ANY LINES?

I was once consulted by an eminent theologian and a
owerful chemist as to whether there are really any such
iings as lines. I drew a chalk-mark on the black-board,
nd used the boundary idea. Along the sides of the chalk-
iark is there a common boundary where the white ends and
ie black begins, neither white nor black but common to both?

Said the theologian, yes. Said the chemist, no.

Though lines are my trade, I sympathized with the chemist.

There is nothing there until I create a line and then see it
iere, if I may say I see what is an invisible creation of my
iind.

Geometry is in structure a system of theorems deduced in
ure logical way from certain unprovable assumptions pre-
reated by auto-active animal and human mind.

14. THE REQUIREMENT OF RIGOR IN REASONING.

Some unscientific minds have a personal antipathy to perfect logical system," "deduced logically from simple fun mental truths." But as Hilbert says: "The requirement rigor, which has become proverbial in mathematics correspo to a universal philosophic necessity of our understandi and, on the other hand, only by satisfying this requirem do the thought content and the suggestiveness of the probl attain their full effect. Besides, it is an error to believe t rigor in the proof is the enemy of simplicity. On the contr we find it confirmed by numerous examples that the rigor method is at the same time the simpler and the more eas comprehended. The very effort for rigor forces us to find simpler methods of proof.

"Let us look at the principles of analysis and geomet The most suggestive and notable achievements of the l century in this field are, as it seems to me, the arithmeti formulation of the concept of the continuum, and the d covery of non-Euclidean geometry."

The importance of the advance they had made was fu realized by John Bolyai and Lobachevski, who claimed once, unflinchingly, that their discovery or creation mark an epoch in human thought so momentous as to be unsurpas by anything recorded in the history of philosophy or scien demonstrating, as had never been proven before, the supre acy of pure reason, at the very moment of overthrowing w had forever seemed its surest possession, the axioms of geo etry.

15. THE YOUTH LOBACHEVSKI.

Young Lobachevski at the University of Kazan, thoug charity student, and, as seeking a learned career, utte dependent on the authorities, yet plunged into all sorts insubordination and wildness. Among other outbursts, night at eleven o'clock he scandalized the despotic Russ authorities of the Tatar town by shooting off a great s

rocket, which prank put him promptly in prison. However, he continued to take part in all practical jokes and horse-play of the more daring students, and the reports of the commandant and inspector are never free from bitter complaints against the outrageous Lobachevski. His place as "Kammerstudent" he lost for too great indulgence toward the misbehavior of the younger students at a Christmas festivity. In spite of all, he ventured to attend a strictly-forbidden masked ball, and what was worse, in discussing the supposed interference of God to make rain, etc., he used expressions which subjected him to the suspicion of atheism. From the continual accusing reports of the commandant to the Rektor, the latter took a grudge against the troublesome Lobachevski, and reported his badness to the Curator, who, in turn, with expressions of intense regret that Lobachevski should so tarnish his brilliant qualities, said he would be forced to inform the Minister of Education. Lobachevski seemed about to pay dear for his youthful wantonness. He was to come up as a candidate for the Master's Degree, but was refused by the Senate, explicitly because of his bad behavior. But his friend the foreign professor of mathematics now rallied the three other foreign professors to save him, if he would appear before the Senate, declare that he rued his evil behavior, and solemnly promise complete betterment.

This was the mettle of the youth, the dare-devil, the irrepressible, who startled the scientific sleep of two thousand years, who contemptuously overthrew the great Legendre, and stood up beside Euclid the god of geometers, this the Lobachevski who knew he was right against a scornful world, who has given us a new freedom to explain and understand our universe and ourselves.

16. THE BOY BOLYAI.

Of the boy Bolyai, joint claimant of the new world, we have a brief picture by his father. "My ($13 + \frac{1}{4}$) year old son, when he reached his ninth year, could do nothing more than speak and write German and Magyar, and tolerably play the violin

by note. He knew not even to add. I began at first with Euclid; then he became familiar with Euler; now he not only knows of Vega (which is my manual in the College) the first two volumes completely, but has also become conversant with the third and fourth volumes. He loves differential and integral calculus, and works in them with extraordinary readiness and ease. Just so he lightly carries the bow through the hardest runs in violin concerts. Now he will soon finish my lectures on physics and chemistry. On these once he also passed with my grown pupils a public examination given in the Latin language, an examination worthy of all praise, where in part others questioned him *ad aperturam*, and in part as opportunity served I let him carry out some proofs in mechanics by the integral calculus, such as variable motion, the *tautochronism* of the cycloid, and the like. Nothing more could be wished. The simplicity, clearness, quickness and ease were enrapturing even for strangers. He has a quick and comprehensive head, and often flashes of *genius*, which many paths at once with a glance find and penetrate. He loves pure deep theories and astronomy. He is handsome and rather strongly built, and appears restful, except that he plays with other children very willingly and with fire. His character is as far as one can judge, firm and noble. I have destined him as a sacrifice to mathematics. He also has consecrated himself thereto."

His mother, née Zsuzsanna Benkő Arkosi, wonderfully beautiful, fascinating, of extraordinary mental capacity, but always nervous, so idolized this only child that when in his fifteenth year he was to be sent to Vienna to the K. K. Ingenieur-Akademie, she said it seemed he should go, but his going would drive her distracted. And so it did.

Appointed "sous-lieutenant," and sent to Temesvár, he wrote thence to his father a letter in Magyar, which I had the good fortune to see at Maros-Vásárhely:

"My Dear and Good Father:

"I have so much to write about my new inventions that it is impossible for the moment to enter into great details,

so I write you only on one-fourth of a sheet. I await your answer to my letter of two sheets; and perhaps I would not have written you before receiving it if I had not wished to address to you the letter I am writing to the Baroness, which letter I pray you to send her.

"First of all I reply to you in regard to the binomial.

*   *   *   *   *   *   *

"Now to something else, so far as space permits.

"I intend to write, as soon as I have put it into order, and when possible to publish, a work on parallels.

"At this moment it is not yet finished, but the way which I have followed promises me with certainty the attainment of the goal, if it in general is attainable.

"It is not yet attained, but I have discovered such magnificent things that I am myself astonished at them. It would be damage eternal if they were lost. When you see them, my father, you yourself will acknowledge it.

"Now I cannot say more, only so much: *that from nothing I have created another wholly new world.*

"All that I have hitherto sent you compares to this only as a house of cards to a castle.

"P. S.—I dare to judge absolutely and with conviction of these works of my spirit before you, my father; I do not fear from you any false interpretation (that certainly I would not merit), which signifies that, in certain regards, I consider you as a second self."

Nor was the young Magyar deceived. The early flashings of his genius culminated here in a piercing search-light penetrating and dissolving the enchanted walls in which Euclid had for two thousand years held captive the human mind.

The potential new universe, whose creation this letter announces, afterward set forth with master strokes in his "Science Absolute of Space," contains the old as nothing more than a special case of the new.

Already all the experts of the mathematical world are his disciples.

17. SOLVING THE UNIVERSE.

Henceforth the non-Euclidean geometry must be reckoned with in all culture, in all scientific thinking. It shows that the riddle of the universe is an indeterminate equation capable of entirely different sets of solutions. It shows that our universe is largely man-made, and must be often remade to be solved.

In "Science" for November 20, 1903, page 643, W. S. Franklin, under a heading for which he shows scant warrant, expresses himself after the following naïve fashion:

"A clear understanding of the essential limitations of systematic physics is important to the engineer; it is I think equally important to the biologist, and it is of vital importance to the physicist, for, in the case of the physicist, to raise the question as to limitations is to raise the question as to whether his science does after all deal with realities, and the conclusion which must force itself on his mind is, I think, that his science, the systematic part of it, comes very near indeed to being a science of unrealities."

Of course, we deeply sympathize with this seemingly sad perception, with its accompanying "simple weeps," "trailing weeps," and "steady weeps," but are tempted to prescribe a tonic or bracer in the form of a correspondence course in non-Euclidean Geometry.

At least in part, space is a creation of the human mind, entering as a subjective contribution into every physical experiment. Experience is, at least in part, created by the subject said to receive it, but really in part making it.

In rigorously founding a science, the ideal is to create a system of assumptions containing an exact and complete description of the relations between the elementary concepts of this science, its statements following from these assumptions by pure deductive logic.

18. GEOMETRY NOT EXPERIMENTAL.

Now, geometry, though a natural science, is not an experimental science. If it ever had an inductive stage, the ex-

periments and inductions must have been made by our prehuman ancestors.

Says one of the two greatest living mathematicians, Poincaré, reviewing the work of the other, Hilbert's transcendently beautiful "Grundlagen der Geometrie":

"What are the fundamental principles of geometry? What is its origin? its nature? its scope? These are questions which have at all times engaged the attention of mathematicians and thinkers, but which took on an entirely new aspect, thanks to the ideas of Lobachevski and of Bolyai.

For a long time we attempted to demonstrate the proposition known as the *postulate of Euclid;* we constantly failed; we know now the reason for these failures.

Lobachevski succeeded in building a logical edifice as coherent as the geometry of Euclid, but in which the famous postulate is assumed false, and in which the sum of the angles of a triangle is always less than two right angles. Riemann devised another logical system, equally free from contradiction, in which this sum is on the other hand always greater than two right angles. These two geometries, that of Lobachevski and that of Riemann, are what are called the *non-Euclidean geometries.* The postulate of Euclid then cannot be demonstrated; and this impossiblity is as absolutely certain as any mathematical truth whatsoever." * * *

"The first thing to do was to enumerate all the axioms of geometry. This was not so easy as one might suppose; there are the axioms which one sees and those which one does not see, which are introduced unconsciously and without being noticed.

"Euclid himself, whom we suppose an impeccable logician, frequently applies axioms which he does not expressly state.

"Is the list of Professor Hilbert final? We may take it to be so, for it seems to have been drawn up with care."

But just here this gives us a startling incident: the two greatest living mathematicians both in error. In my own class a young man under twenty, R. L. Moore, proved that of Hilbert's "betweenness" assumptions, axioms of order, one of the five is redundant, and by a proof so simple and

elegant as to be astonishing. Hilbert has since acknowledged this redundancy.

The same review touches another fundamental point as follows:

"Hilbert's Fourth Book treats of the measurement of plane surfaces. If this measurement can be easily established without the aid of the principle of Archimedes, it is because two equivalent polygons can either be decomposed into triangles in such a way that the component triangles of the one and those of the other are equal each to each (so that, in other words, one polygon can be converted into the other after the manner of the Chinese puzzle [by cutting it up and rearranging the pieces]), or else can be regarded as the difference of polygons capable of this mode of decomposition (this is really the same process, admitting not only positive triangles but also negative triangles.)

"But we must observe that an analogous state of affairs does not seem to exist in the case of two equivalent polyhedra, so that it becomes a question whether we can determine the volume of the pyramid, for example, without an appeal more or less disguised to the infinitesimal calculus. It is, then, not certain whether we could dispense with the axiom of Archimedes as easily in the measurement of volumes as in that of plane areas. Moreover, Professor Hilbert has not attempted it."

Max Dehn, a young man of twenty-one, in Mathematische Annalen, Band 55, proved that the treatment of equivalence by cutting into a finite number of parts congruent in pairs, can never be extended from two to three dimensions.

Poincaré's Review first appeared in September, 1902. But on July 1, 1902, I had already presented before this very Section, a complete solution of the question or problem he proposes, the determination of volume without any appeal to the infinitesimal calculus, without any use of the axiom of Archimedes.

19. THE TEACHING OF GEOMETRY.

As Study has said: "Among conditions to a more profound understanding of even very elementary parts of the Euclidean geometry, the knowledge of the non-Euclidean geometry cannot be dispensed with."

How shall we make this new creation, so fruitful already for the theory of knowledge, for kenlore, bear fruit for the teaching of geometry? What new ways are opened by this masterful explosion of pure genius, shattering the mirrors which had so dazzlingly protected from perception both the flaws and triumphs of the old Greek's marvelous, if artificial, construction?

One advance has been safely won and may be rested on. There should be a preliminary course of intuitive geometry which does not strive to be rigorously demonstrative, which emphasizes the sensuous rather than the rational, giving full scope for those new fads, the using of pads of squared paper, and the so-called laboratory methods so well adapted for the feeble-minded. Hailmann, in his preface, sums up "the purpose throughout" in these significant words: "And thus, *incidentally*, to stimulate genuine vital interest in the study of geometry."

I remember Sylvester's smile when he told me he had never owned a mathematical or drawing instrument in his life.

His great twin brother, Cayley, speaks of space as "the representation [creation] lying at the foundation of all external experience." "And these objects, points, lines, circles, etc., in the mathematical sense of the terms, have a likeness to, and are represented more or less imperfectly, and from a geometer's point of view, *no matter how imperfectly*, by corresponding physical points, lines, circles, etc."

But geometry, always relied upon for training in the logic of science, for teaching what demonstration really is, must be made more worthy the world's faith. There is need of a text-book of rational geometry really rigorous, a book to give every clear-headed youth the benefit of his living after Bolyai and Hilbert.

20. THE NEW RATIONAL GEOMETRY.

The new system will begin with still simpler ideas than did the great Alexandrian, for example, the "betweenness" assumptions; but can confound objectors by avoiding the old matters and methods which have been the chief points of objection and contest. For example, says Mr. Perry, "I wasted much precious time of my life on the fifth book of Euclid." Says the great Cayley: "There is hardly anything in mathematics more beautiful than his wondrous fifth book."

For my own part, nothing ever better repaid study. But the contest is over, for now, at last, without sacrificing a whit of rigor, we are able to give the whole matter by an algebra as simple as if only approximate, and, like Euclid, including incommensurables without even mentioning them.

Again, we shall regain the pristine purity of Euclid in the matter of what Jules Andrade calls "cette malheureuse et illogique definition" (Phillips and Fisher, §7): "A straight line is a line which is the shortest path between two of its points."

As to this hopeless muddle, which has been condemned *ad nauseam*, notice that it is senseless without a definition for the length of a curve. Yet, Professor A. Lodge, in a Discussion on Reform, says: "I believe we could not do better than adopt some French text-book as our model. Also I, 24, 25, being obviously related to I, 4, are made to immediately follow it in such of the French books as define a straight line to be the shortest distance between two points." Professor Lodge, then, does not know that the French themselves have repudiated this nauseous pseudo-definition. Of it Laisan says (p. 223): "This definition, almost unanimously abandoned, represents one of the most remarkable examples of the persistence with which an absurdity can propagate itsel throughout the centuries.

"In the first place, the idea expressed is incomprehensibl to beginners, since it presupposes the notion of the lengtl of a curve; and further, it is a vicious circle, since the lengtl of a curve can only be understood as the limit of a sum o

rectilinear lengths; moreover, it is not a definition at all, since, on the contrary, it is a demonstrable proposition."

As to what a tremendous affair this proposition really is, consult Georg Hamel in Mathematische Annalen for this very year (page 242), who employs to adequately express its content the refinements of the Integral Calculus and the modern Theory of Functions.

Moreover, underneath all this even is the assumption of the theorem, Euclid I, 20: "Any two sides of a triangle are together greater than the third side;" upon which proposition, which the Sophists said even donkeys knew, Hilbert has thrown brilliant new light in the Proceedings of the London Mathematical Society, 1902, pages 50–68, where he creates a geometry in which the donkeys are mistaken, a geometry in which two sides of a triangle may be together *less* than the third side, exhibiting as a specific and definite example a right triangle in which the sum of the two sides is less than the hypothenuse.

Any respectably educated person knows that in general the length of a curve is defined by the aggregate formed by the lengths of a proper sequence of inscribed polygons.

The curve of itself has no length. This definition in ordinary cases creates for the curve a length; but in case the aggregate is not convergent, the curve is regarded as not rectifiable. It had no length, and even our creative definition has failed to endow it with length; so it has no length, and lengthless it must remain.

If, however, it can be shown that the lengths of these inscribed polygons form a convergent aggregate which is independent of the particular choice of the polygons of the sequence, the curve is rectifiable, its length being defined by the number given by the aggregate.

21. GEOMETRY WITHOUT ANY CONTINUITY ASSUMPTION.

Euclid in his very first proposition and again in I, 22, "to make a triangle from given sides," uses unannounced a continuity assumption. But nearly the whole of Euclid can be

obtained without any continuity assumption whatever, and this great part it is which forms the real domain of Elementary Geometry.

Continuity belongs, with limits and infinitesimals, in the Calculus.

Professor W. G. Alexejeff of Dorpat, in "Die Mathematik als Grundlage der Kritik wissenschaftlich-philosophischer Weltanschanung" (1903), shows how men of science have stultified themselves by ignorantly presupposing continuity. He calls that a higher standpoint which takes account of the individuality of the elements, and gives as examples of this discreet or discontinuous mathematics the beautiful enumerative geometry, the Invariants of Sylvester and Cayley, and in chemistry the atomic-structure theory of Kekulé and the periodic system of the chemical elements by Mendelejev, to which two theories, both exclusively discreet in character, we may safely attribute almost entirely the present standpoint of the science.

Still more must discontinuity play the chief rôle in Biology and Sociology, dealing as they do with differing individuals, cells and persons. How desirable, then, that the new freedom should appear even as early as in elementary geometry.

After mathematicians all knew that number is in origin and basis entirely independent of measurement or measurable magnitude; after in fact the dominant trend of all pure mathematics was its arithmetization, weeding out as irrelevant any fundamental use of measurement or measurable quantity, there originated in Chicago from the urbane Professor Dewey (who in parenthesis I must thank for his amiable courtesy throughout the article in the Educational Review which he devoted to my paper on the Teaching of Geometry) the shocking tumble or reversal that the origin, basis and essence of number is measurement.

Many unfortunate teachers and professors of pedagogy ran after the new darkness, and even books were issued trying to teach how to use these dark lines in the spectrum for illuminating purposes.

There is a ludicrous element in the parody of all this just now in the domain of geometry.

After mathematicians all know of the wondrous fruit and outcome of the non-Euclidean geometry in removing all the difficulties of pure elementary geometry, there comes another philosopher, a Mr. Perry, who never having by any chance heard of all this, advises the cure of these troubles by the abolition of rational geometry.

Just as there was a Dewey movement so is there a Perry movement, with books on geometry written by persons who never read Alice in Wonderland or its companion volume, Euclid and his Modern Rivals.

But the spirits of Bolyai and Lobachevski smile on this well-meaning strenuosity, and whisper, "It is something to know what proof is and what it is not; and where can this be better learned than in a science which has never had to take one footstep backward?"

PAPERS READ.

A New Treatment of Volume. By G. B. Halsted.

Lines on the Pseudosphere and the Syntractrix of Revolution. By E. L. Hancock.

The Rotation Period of the Planet Saturn. By G. W. Hough.

An Extension of the Group Concept. By Edward Kasner.

Facilities for Astronomical Photography in Southern California. By E. L. Larkin.

Coincident Variations. By L. S. McCoy.

On the Generalization and Extension of Sylow's Theorem. By G. A. Miller.

The Supporting and Counterweighting of the Principal Axes of Large Telescopes. By C. D. Perrine.

A Linkage for Describing the Conic Sections by Continuous Motion. By J. J. Quinn.

Circles Represented by $\mu^2 P + L\mu^2 Q + M\mu R + N S = 0$. By T. R. Running.

A New Type of Transit-Room Shutter. By David Todd.

[The following papers were read before the Astronomical and Astrophysical Society of America, and Section A, in joint session.]

THE PREDICTION OF OCCULTATIONS OF STARS BY THE MOON. BY G. W. HOUGH.

THE D. O. MILLS EXPEDITION. BY W. W. CAMPBELL.

THE SUN'S MOTION RELATIVE TO A GROUP OF FAINT STARS. BY G. C. COMSTOCK.

THE ABSORPTION OF SOLAR RADIATION BY THE SUN'S ATMOSPHERE. BY F. W. VERY.

BORELLY'S COMET. BY SEBASTIAN ALBRECHT.

THE PIVOTS OF THE NINE-INCH TRANSIT CIRCLE OF THE U. S. NAVAL OBSERVATORY. BY W. S. EICHELBERGER.

A SHORT SKETCH OF THE PROGRESS OF ASTRONOMY IN THE UNITED STATES. BY M. S. BRENNAN.

THE EROS PARALLAX PHOTOGRAPHS AT THE GOODSELL OBSERVATORY. BY H. C. WILSON.

[The following papers were read before the Chicago Section of the American Mathematical Society, and Section A, in joint session.]

A Generalization of Symmetric ahd Skew Symmetric Determinants. By L. E. Dickson.

A Class of Pseudo-Contact Transformations. By E. R. Hedrick.

Some Developments in Vector Analysis. By J. V. Collins.

Primitive Roots of an Ideal in an Algebraic Number Field. By Jacob Westlund.

The Elliptic Functions and the General Symmetric Group on Four Letters. By E. W. Davis.

An Existence Theorem for a Differential Equation of the Second Order, with an Application to the Calculus of Variations. By G. A. Bliss.

Analogues of the Jacobian Identity that Involve Four Elements. By Oscar Schmiedel.

The Law of the Mean for Functions of Several Variables. By E. R. Hedrick.

Algebras Defined by Finite Groups. By J. B. Shaw.

The Definition of a Reducible Hyper-Complex Number System. By Saul Epsteen.

Memoir on Abelian Transformations. By L. E. Dickson.

Groups in which Certain Commutative Operations are Conjugate; and Complete Sets of Conjugate Operations. By H. L. Rietz.

Group Characters of a Linear Fractional Group; of Linear Homogeneous Groups of Determinant Unity; and of the Group of all Linear Fractional Substitutions in a Galois Field. By H. E. Jordan.

SECTION B.

PHYSICS.

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PAPERS READ.

Report of the Committee on the Velocity of Light. By D. B. Brace.

A Half Shade Elliptical Polarizer and Compensator. By D. B. Brace.

On the Effect of a Magnetic Field on the Interference of Natural Light. By John Mills.

On the Velocity of Light in a Magnetic Field. By John Mills.

Hertzian Waves Since Hertz. By A. D. Cole.

A Simple Alternate Current Frequency Recorder. By E. S. Johonnott.

Iron Losses in Loaded Transformers. By E. S. Johonnott

A Method of Comparing Standard Cells. By A. C. Longden.

A Method for the Determination of Mutual Induction Coefficients. By Augustus Trowbridge.

The Influence of Occluded Hydrogen on the Electrical Resistance of Palladium. By W. E. McElfresh.

On Hydrogen-charged Palladium. By E. H. Hall.

A New Form of Frequency Meter. By A. S. Langsdorf.

A Remarkable Distribution of Carbon on the Bulb of a 'Hylo' Incandescent Lamp. By Arthur L. Foley.

On the Charges given to Surfaces by the Diffusion of Ions and the Earth's Negative Potential. By John Zeleny.

The Rate of Propagation of Smell. By John Zeleny.

On the Theory of the Electrolytic Rectifier. By S. R. Cook.

On the Position of Aluminum in the Voltaic Series and the Use of Aluminum as a Positive Element in a Primary Cell. By S. R. Cook.

A New Method for Quantitive Work in Sound. By John O. Reed.

On the Differential Telephone. By William Duane.

The Selective Reflection of Fuchsin. By W. B. Cartmel.

Primitive Conditions in the Solar Nebula. By Francis E. Nipher.

On the Investigation of the Kinetic Theory of Gases by Elementary Methods. By Henry T. Eddy.

A Demonstration to Disprove the Second Law of Thermodynamics. By Jacob T. Wainwright.

Determination of the Coefficient of Expansion of Quartz and Nickel at High Temperatures. By John O. Reed and H. M. Randall.

On the Thickness of Absorbed Aqueous Films. By Lyman J. Briggs and A. W. McCall.

On the Heat Developed on Moistening Insoluble Powders. By Lyman J. Briggs.

The Continuous Method of Steam Calorimetry. By Joseph H. Hart.

The Circulation of the Atmosphere, as indicated by the recent Abnormal Sky Colors. By A. Lawrence Rotch.

[The following papers were read before the American Physical Society and Section B, in joint session.]

THE RADIOACTIVITY OF ORDINARY METALS. BY E. F. BURTON.

DOES THE RADIOACTIVITY OF RADIUM DEPEND ON THE CONCENTRATION? BY E. RUTHERFORD.

THE HEATING EFFECT OF THE RADIUM EMANATIONS. BY E. RUTHERFORD AND H. T. BARNES.

THE PHOSPHORESCENCE OF ORGANIC SUBSTANCES AT LOW TEMPERATURES. BY E. L. NICHOLS AND ERNEST MERRITT.

THE SPECTRO-PHOTOMETRIC STUDY OF FLUORESENCE. BY E. L. NICHOLS AND ERNEST MERRITT.

THE ELECTRICAL CONDUCTIVITY OF LIQUID FILMS. BY LYMAN J. BRIGGS.

ON THE USE OF NICKEL IN THE MARCONI MAGNETIC DETECTOR. BY ARTHUR L. FOLEY.

ON DOUBLE REFRACTION IN MATTER MOVING THROUGH THE ETHER. BY D. B. BRACE.

The Work of the National Bureau of Standards. By E. B. Rosa.

Electric Double Refraction in Gases. By D. B. Brace.

The Spectrum of the Afterglow of the Spark Discharge in Nitrogen at Low Pressures. By Percival Lewis.

The Spectrum of the Electrodeless Discharge in Nitrogen. By Percival Lewis.

SECTION C.

CHEMISTRY.

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ADDRESS

BY

CHARLES BASKERVILLE,

VICE-PRESIDENT AND CHAIRMAN OF SECTION C FOR 1903.

THE ELEMENTS: VERIFIED AND UNVERIFIED.

It is the sad duty of the retiring Chairman of this Section o chronicle the death of two members. One of them, James Francis Magee, B. S., University of Pennsylvania, 1887, levoted his life chiefly to commercial pursuits, in which ie was most successful. He joined the Association at the ifty-first meeting, being one of our youngest. The other was I. Carrington Bolton, Columbia, 1862 (Ph. D., Göttingen, 867), who, with the exception of four (Gibbs, Boye, Brush, nd Hilgard), was the senior of the Section, having joined at he seventeenth meeting. I beg permission to quote from n article of his in the *American Chemist*, 1876, the year folowing his elevation to Fellowship in the Association, as it xemplified in telling words one of the great aims in his life, vith the fruitful accomplishment of which you are familiar.

"So rapid are the strides made by science in this progressive ge, and so boundless is its range, that those who view its areer from without find great difficulty in following its dierse and intricate pathways, while those who have secured footing within the same road are often quite unable to keep ace with its fleet movements and would fain retire from he unequal contest. It is not surprising, then, that those ctually contributing to the advancement of science, pressing agerly upward and onward, should neglect to look back upon he labors of those who precede them, and should sometimes se sight of the obligations which science owes to forgotten

generations."* His numerous contributions to and intimate knowledge of the history of chemistry; his gentle and generous sympathy aided and stimulated many active in research or technical applications of chemistry. His monumental bibliographies put out by the Smithsonian Institution are masterpieces. The grief and keen regret of his loss are not confined to one nation.

On another occasion it has been the good fortune of him who has the honor of addressing you to-day to indicate that events of literary moment, governmental modifications, inventions and forward stridings in science have apparently accommodated themselves to historical periods during the past century.† Striking novel facts and fancies, gleaned in the realm of inorganic chemistry, have crested not a few of the high waves of those human tides that beat against the coast of the untried and unknown.

The human mind knows by contrasts. For the day we have night; for the good there is evil. Where man would have a God, he had also a devil; for the true there is the false; the verified and unverified. The false may be true through ignorance; the true may be false in the light of new knowledge. Or, as Hegel put it, "*Sein und das nicht Sein sind das Nämliche.*"

Is matter continuous or discrete? argued the opposed schools of Grecian philosophy led by Leucippus, Democritus and Epicurus, and dominated by Aristotle. Despite the clarity of the statements of the Roman Lucretius,‡ the atomic

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*"Notes on the Early Literature of Chemistry—The Book of the Balance of Wisdom," New York Academy of Sciences, May 29, 1876.

†"The Rare Earth Crusade: What it Portends, Scientifically and Technically," *Science*, N. S. 17, 722-781.

‡"Nature reserving these as seeds of things
Permits in them no minish nor decay;
They can't be fewer and they can't be less."

Again of compounds—

"Decay of some leaves others free to grow
And thus the sum of things rests unimpaired."
—Book II, 79.

hypothesis received scant attention until the seventeenth century of the Christian era, when Galilei's experimental science assailed Aristotelian metaphysics and demanded verifications of the premises of that philosophy, which had governed all the schools of Europe for two thousand years.* While Gassendi, Boyle, Descartes, Newton, perhaps Boscovich, Lavoisier, Swedenborg, Richter, Fischer and Higgins had to do with our modern atomic theory, Dalton one hundred years ago "created a working tool of extraordinary power and usefulness" in the laws of definite and multiple proportions. As Clarke† remarked, "Between the atoms of Lucretius and the Daltonian atom, the kinship is very remote." Although the lineage is direct, the work of Berzelius, Gmelin and others; the laws of Faraday, Guy Lussac, Agavadro, Dulong and Petit; the reformations of Laurent and Gerhardt, but particularly Cannizzaro; the systematizations of de Chancourtois, Newlands, Hinrichs, Mendelejeff and Lothar Meyer; the stereo-chemistry of Van't Hoff and LeBel, have imperialized the ideas of the Manchester philosopher, so that the conceptions of the conservative atomists of to-day are quite different from those at the beginning of the closed century.‡

These have not come about solely through the additive labors of the savants mentioned, for they have been shaped quite as much by speculative and experimental opposition exemplified by Brodie§ and Sterry Hunt.‖

In Graham's "Speculative Ideas Respecting the Constitution of Matter,"¶ we have the conception that our supposed

*See "The Atomic Theory," The Wilde Lecture, by F. W. Clarke, at Dalton Celebration, May, 1903.

†*Loc. cit.*

‡While I have examined much of the original literature, Venable's "History of the Periodic Law" has been most helpful. I have furthermore had the privilege of reading very carefully the manuscript of a work entitled "The Study of the Atom" (in press) by Dr. Venable.

§"Calculus of Chemical Operations," J. Chem. Soc., 21, 367 (1866), and his book, "Ideal Chemistry" (1880).

‖Numerous papers summarized in "A New Basis for Chemistry," New York, 1887 and 1892 (4th edition).

¶Proc. Roy. Soc., 1863.

elements possess "one and the same ultimate or atomic molecule existing in different conditions of movement."* *Apropos*, we have the suggestion of F. W. Clarke† that the evolution of planets from nebulæ, according to the hypothesis of Kant and Laplace, was accompanied by an evolution of the elements themselves. Even Boyle—"the cautious and doubting Robert Boyle," as Humboldt said of him—was inclined to the belief that "all matter is compounded of one primordial substance—merely modifications of the *materia prima.*"

The Daltonian ideas had scarcely reached adolescence before Prout (1815), giving heed to the figures concerned, would have all the elements compounded of hydrogen. The classical atomic mass values obtained by sympathetic Stas and the numerous investigations of those who followed him, with all the refinements human ingenuity has been able to devise, temporarily silenced such speculations, but not until Marignac had halved the unit, Dumas had quartered it, and Zängerle, as late as 1882, insisted upon the one-thousandth hydrogen atom.

The notion, like Banquo's ghost, will ever up, for if one may judge from the probability calculations of Mallet‡ and Strutt§, a profound truth underlies the now crude hypothesis.

Crookes,‖ from observations made during prolonged and painstaking fractionations of certain of the rare earths, supported his previously announced "provisional hypothesis" as to the genesis of the elements from a hypothetical *protyle*, which existed when the universe was without form and void. He designated those intermediate entities, like yttrium, gadolinium and didymium, "meta-elements,"¶ a species of compound radicals, as it were. *Urstoff*, fire mist, protyle, the ultra-

*Venable, "The Definition of the Element," Vice-Presidential Address, Section C, A. A. A. S., Columbus Meeting, 1899.

†"Evolution and the Spectroscope," Pop. Sc. M. Jour., 1873.

‡Phil. Trans., 171, 1003 (1881).

§Phil. Mag. (6), 1, 311.

‖Chem. News, 55, 83 (1886).

¶Address before Chemical Section of the British Association, Chem. News, 54, 117 (1885).

gaseous form, the fourth state of matter* was condensed by a process analogous to cooling; in short, the elements were created. The rate of the cooling and irregular condensation produced "the atavism of the elements," and this caused the formation of the natural families of the periodic system. Marignac†, criticising this hypothesis, states "I have always admitted‡ the impossibility of accounting for the curious relations which are manifested between the atomic weights of the elements, except, by the hypothesis, by a general method of formation according to definite though unknown laws; even when these relations have the character of general and absolute laws."

Further, "I do not the less acknowledge that the effect of constant association of these elements is one of the strongest proofs that can be found of the community of their origin. Besides, it is not an isolated fact; we can find other examples, such as the habitual association in minerals of tantalum, niobium and titanium."

Sir John Herschel thought that all the atoms were alike and the elements, as we know them, "have the stamp of the manufactured article."

Hartley§ this year says: "It is more than twenty years since the study of homology in spectra led me to the conviction that the chemical atoms are not the ultimate particles of matter, and that they have a complex constitution."

The peculiar discharge from the negative electrode of a vacuum tube was investigated many years ago by Hittorf and Crookes, who arrived at the conclusion that it was composed of streams of charged particles. All are familiar with the very recent proposed "electrons" and "corpuscles" resulting from the beautiful physical researches of Lodge and J. J. Thomson. These appear to have caused a trembling in the

*Crookes, Royal Societies, June 10, 1880.

†Archives des Sciences Physiques et Naturelles, 17–5; Chemical News, 56, 39.

‡Remarks made in 1860–65 after publication of Stas' "Researches on Atomic Weights," Archives, 9, 102, 24–376.

§Address before the Chemical Section, British Association, Southport meeting, Sept., 1903. Chem. News, 88, 154.

belief of many in the immutability of the atom, and the complete abandonment of the atom is seriously discussed by others.

"If the electrons of all elements are exactly alike, or, in other words, if there is but one matter, just as there is but one force, and if the elements be but the various manifestations of that one matter, due to a different orbital arrangement of the electrons, it would seem that we are fast returning to the conceptions of the middle-age alchemist. The transmutations of metals involves but the modification of the arrangement of the electrons." Such efforts as Fittica's* should not be treated with scorn, but given the careful examination and merited consideration, as Winkler† gave his. Science should thus ever be a "foe of raw haste, half-sister to delay."‡

Although by chemical means, so far, we have been unable to break up the atom, apparently electrical energy, in the form of cathode rays, for example, follows the grain of atomic structure. Some advanced thinkers look upon the atoms as disembodied charges of electricity. Ostwald has taught it. Electric charges are known only as united to matter, yet Johnstone Stoney and Larmor have speculated on the properties of such charges isolated. "Such a charge is inertia, even though attached to no matter, and the increase of inertia of a body due to electrification has been calculated by both Thomson and Oliver Heaviside, the conception accordingly being advanced that all inertia is electrical and that matter, as we know it, is built up of interlocked positive and negative electrons. If it were possible in any mass of matter to separate these electrons, then matter would disappear and there would remain merely two enormous charges of electricity." We are aware of phenomena attributed to the negative electrons; we await anxiously the announcement of the positive electrons. But here the water is deep and one may not swim too well.

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*"Black Phosphorus, or Conversion of Phosphorus into Arsenic," Chem. News, 81, 257, and 82, 166.

†Berichte, 33, 10; Chem. News, 81, 305.

‡Van Dyke in "The Ruling Passion."

We do know, however, as A. A. Noyes says,* that "there exists in the universe some thing or things other than matter which, by association with it, gives rise to the changes in properties which bodies exhibit, and gives them power of producing changes in the properties of other bodies." Further (page 15). " . . . matter is that which gives rise to the localization of the complex of properties which certain portions of space exhibit. Even though, on the one hand, it must be admitted that the existence of matter is inferred only from various energy manifestations which bodies exhibit, it must be acknowledged, on the other, that there are no manifestations of energy except those which are associated with the manifestations of it that have led to the adoption of the concept of matter; in a word, the two assumed entities, matter and energy, are indissolubly connected in our experience." Thus, as Dumas said, "Hypotheses are the crutches of science to be thrown away at the proper time."

I have dared to sketch these conceptions in a few bold outlines, for

> "We can't enumerate them all!
> In every land and age have they
> With honest zeal been toiling on†
> To turn our darkness into day."

The imposition upon your good nature practiced in the foregoing craves its pardon in an effort to seek a definition for the term element. Shall we say, as does Remsen, "An element is a substance made up of atoms of the same kind?" Can we say that it is not? Venable‡ truly says "An element is best defined by means of its properties." These conceits are not exclusive. The properties are the result of the action of physical forces and chemical affinity, whatever that may be. Certain of the novel atmospheric gases have so far responded but poorly to the latter, as predicted before their discovery by Flawitzsky, Julius Thomsen and de Boisbaudran in 1887.

*"General Principles of Physical Science," p. 13 (1902).
†Aikens' poem at Priestley Centennial, Am. Chemist, 1875, 23.
‡The "Definition of the Element," *loc. cit.*

This necessitates, according to Piccini,* our dividing them at once into two classes.

Pattison Muir gives a satisfactory definition.† "The notion of the elements that has been attained after long continued labor is that of certain distinct kinds of matter, each of which has properties that distinguish it from every other kind of matter, no one of which has been separated into portions unlike the original substance, and which combine together to produce new kinds of matter that are called compounds."

The following simpler definition has finally served as my guide: *An element is that which has not been decomposed, so far as we are aware, into anything other than itself.* In short, it is consistent.

It is well to stop occasionally and take stock. The Daltonian centenary could not but be an opportune time. Stable, certified securities are not enumerated in the list which follows. Having in mind the second chapter of the First Book of Chronicles, certain so-called elements are mentioned, for yttrium begat cerium, and cerium begat lanthanum, and lanthanum begat samarium and didymium, and didymium begat neodidymium and præseodidymium, and præseodidymium begat α- and β-præseodidymium, "*und so weiter*."

Unpracticed as a reading clerk, I shall spare you the strain of hearing this long list of elements on probation, but submit for leisure perusal printed copies. (See Appendix.)

From the table have been omitted Urstoff, protyle, (Crookes), electrons (Lodge), corpuscles (J. J. Thomson) and pantogen (Hinrichs). It appeared also unnecessary to incorporate phlogiston, nitricum (the imaginary body, thought by Berzelius, united with oxygen to form nitrogen), and aræon (ponderable caloric). According to Meissner, hydrochloric acid is composed of two equivalents of oxygen, one of water, combined with aræon and the imaginary radical murium (*vide* Bolton). Often alloys have been prepared and given

*Zeit. Anorg. Chem., 19, 295 (1899).

†"The Alchemical Essence and the Chemical Element," London, 8vo., pp. 94 (1894).

names like the elements, "Magnalium" for example. These are omitted also. Otherwise, I have purposely included every suggestion of an element I could obtain. The summary, while doubtless deficient, may secure an historical vindication.

The italicised names are elements which have been tried and found wanting; those in small capitals have been verified beyond question as distinct, although in specific cases evidence is had that they are complex. All others uniformly stand before the bar of judgment. The arrangement is chronological. Due to pressure of affairs, it has been quite impossible in some cases to consult the original papers, hence part of the table is composed of second-hand and meager information. Every source available has been drawn upon, as Venable's "The Elements, Historically Considered" [Journ. Elisha Mitchell Scientific Society, IV, 36, (1887)], which unfortunately gives no references; Winkler's "The Discovery of New Elements within the last Twenty-five Years" (Lecture before the German Chemical Society, Smithsonian Report for 1897, 237); Clere's "Marignac Memorial Lecture," 1895; "Rise and Fall of the Defunct Elements" [Chem. News, 22, 208, (1870)]; "List of Elementary Substances Announced from 1877 to 1887" (Chem. News, 58, 1887), by the lamented H. Carrington Bolton, to whom I cannot too strongly emphasize my indebtedness for his ever ready help and sympathy.

It is my desire to have this as complete and authentic as possible. I therefore beg that all information as to omissions and corrections be forwarded me (Chapel Hill, North Carolina, U. S. A.). It will be gratefully acknowledged.

What shall we do with these numerous aspirants whose recognition is urged? "These elements perplex us in our researches, baffle us in our speculations, and haunt us in our very dreams. They stretch like an unknown sea before us, mocking, mystifying and murmuring strange revelations and possibilities," said Crookes referring to the rare earths. Some have been verified, many unverified; some are true, some are false. Without doubt some have been presented without sufficient stage setting, yet the good faith of many cannot be questioned. In fact, from this list, as one reads he perceives

the whole gamut of scientific emotions. There he may find the tragedies of elemental pretension, the comedies, yea! the very farces.

We need not look far to ascertain explanations for certain incorrect conclusions. The extreme rarity of the minerals in which many of the tentative elements have been detected, the excessively small percentages of the new ingredients, and the extraordinary difficulties attending their separation from known and unknown substances combine to render the investigations laborious, protracted and costly. De Boisbaudran required 2,400 kilograms of zinc blende for 62 grams of gallium. Ramsay* has shown one part of crypton in twenty million volumes of air, while a like amount of xenon requires one hundred and seventy million. How patiently and persistently that modest Parisian couple followed Becquerel's rays !

Furthermore, when one feels that he has obtained something novel, the absolute proof is fraught with difficulties and uncertainties. We have decided to define an element by its properties. The alterations produced in the properties of the most characteristic elements by the presence of small amounts of foreign substances are evident in steel. The influence of arsenic upon the conductivity of copper is well known, and Le Bon† has recently shown that traces of magnesium (one part in 14,000) in mercury cause the latter to decompose water and to rapidly oxidize in the air at ordinary temperatures. Thorium with less than a trace of actinium produces an autophotograph.

This point cannot be strongly stressed in the rare earth field. One who has wrought with thorium dioxide well knows the influence a small amount of cerium has upon its solubility. The conflicting statements in the literature as to the colors of the oxides of the complexes, neodidymium and præseodidymium, cause one to wonder if different researchers have had the same hæcceity.

An appeal to the spectroscope is of course in the minds of all my hearers.

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*Zeit. phys. Chem., 44, 74 (1903).
†Compt. rend., 131, 706 (1900).

It was once supposed that each element has its characteristic spectrum which remained the same under all circumstances. Keeler* calls attention to modern investigations which have shown that the same element can have entirely different spectra. For example, oxygen may be caused to have five different spectra, nitrogen two, etc. In fact, there is no indication in the appearance of the spectra that they belong to the same substance; yet through the result of the work of Rydberg, Kayser, Runge, and Precht, series of groups of lines are had which satisfy mathematical formulæ.

"It was proposed by de Gramont, at the International Congress in Paris, in 1900, and agreed, that no new substance should be described as an element until its spark spectrum had been measured and shown to be different from that of every other known form of matter." As Hartley† remarks, "This appears to me to have been one of the most important transactions of the Congress." Radium‡ was the first to be tested by this rule. Exner and Haschek obtained 1193 spark and 257 arc lines for Demarcay's europium. It must not be forgotten, however, that by overlapping lines in mixtures may be masked or appear, which are absent in those bodies of the highest state of purity. It must not be forgotten that pressure influences the spectrum, usually producing a broadening of the lines, as shown by Schuster,§ and that it may occur symmetrically or only towards the least refrangible red. Lest we forget, the spectroscope failed a long time to show radium, and we knew it was there. It must not be forgotten, as G. Krüss‖ has shown that the "influence of temperature can-

*Scientific American Supplement, 88, 977, 1894, and Popular Astronomy.

†Address before the Chemical Section of the British Association, Southport, 1903.

‡Runge and Precht, Ann. Physik., IV, 12, 407 (1903).

§British Association Report, 1880, 275. *Vide* also Lockyer and Frankland, Proc. Roy. Soc., 27, 288 (1869).

‖"The Influence of Temperature upon the Spectrum; Analytical Observations and Measurements," Liebig's Annalen, 238, 57; Chem. News, 56, 51.

not be neglected and ignored, but must be considered by every chemist who wishes to make correct spectroscopic observations." It is well known to spectroscopists that band spectra are obtained at temperatures intermediate between those required for the production of continuous spectra and line spectra.* The explanations of these facts do not concern us at present.

It has been shown by the researches of Newton, Dale, Gladstone, Jamin, Schrauff, Landolt, and others that the refractive power increases in all liquids, except in water, between 0° and 4° with the increase of density—that is, with decrease of temperature. Rydberg showed that various solid bodies, such as quartz and aragonite, follow the same law. There are some exceptions, however. Among these is glass, as proved by Arago and Neumann prior to Rydberg. "On a rise of temperature all phenomena of absorption or emission are displaced toward the violet with the glass prism, but toward the red with quartz prisms. These displacements are the greater the more refrangible the region of the spectrum in which they occur." As the result of a large number of observations, Krüss learned that by a variation of 25°, marked changes would be observed in the spectroscopic lines. From a table given, it could be seen that errors may spring from neglect of the temperature (of the instrument) in stating wave-lengths, since a rise of 5° is sufficient to transfer the D_1 to the position D_2. Roscoe obtained an entirely new spectrum with the metal sodium whereby it appears that this metal exists in a gaseous state in four different degrees of aggregation, as a simple molecule, and as three or four or eight molecules together.

Grünwald in a series of papers on his theory of spectrum analysis† endeavors "to discover relations between the spectra

*Spectrum Analysis, Landauer, English translation by Tingle, p. 70.

†*a*. "Uber das Wasserspectrum, das Hydrogen—und Oxygen spectrum," Phil. Mag., 24, 304 (1887).

b. "Math. Spectralanalyse des Magnesiums und der Kohle," Monatshefte für Chemie, 8, 650.

c. "Math. Spectralanalyse des Kadmiums," Monatshefte für Chemie, 9, 956.

and thus to arrive at simpler, if not fundamental, "elements." He came to the conclusion that "all the so-called elements are compounds of the primary elements *a* and *b*" (coronium and helium). Ames,* having called attention to the use of uncorrected data by Grünwald, remarks, "The concave-grating gives the only accurate method of determining the ultra-violet wave-lengths of the elements; and as a consequence of not using it most of the tables of wave-lengths so far published are not of much value."

Hutchins and Holden,† after a comparative study of the arc spectra of metals and the sun with a twenty-one foot focal Rowland grating, state: "We are convinced that there is much in the whole matter of coincidences of metallic and solar lines that needs re-examination; that something more than the mere coincidence of two or three lines out of many is necessary to establish even the probability of the presence of a metal in the sun. With the best instruments the violet portion of the solar spectrum is found to be so thickly set with fine lines that, if a metallic line were projected upon it at random, in many places the chances for a coincidence would be even, and coincidences could not fail to occur in case of such metals as cerium and vanadium, which give hundreds of lines in the arc."

"Moreover, a high dispersion shows that very few lines of metals are simple and short, but, on the contrary, winged and nebulous, and complicated by a great variety of reversal phenomena. A 'line' is sometimes half an inch wide on the photographic plate, or it may be split into ten by reversals."

Lockyer maintained that the lines of certain substances vary not only in length and in number, but also in brilliancy and in breadth, depending upon the quantity of the substance as well as temperature.‡ Being unable to decompose the elements in the laboratory, he studied the spectra of the stars. The spectra of the colder stars§ show many more metals,

*Am. Chem. J., 11, 138 (1889).

†"On the Existence of Certain Elements, Together with the Discovery of Platinum in the Sun." Am. Jour. Sci.; Sci. Am. Supp., 25, 628, 1888.

‡Roy. Soc. Proc., 61, 148, 183; Chem. News, 79, 145.

§Chem. News, 79, 147.

but no metalloids, whereas the coldest stars, *A. Orionis*, show the Crookes' spectrum of metalloids which are compounds. None of the metalloids are found in the spectrum of the sun. Over 100,000 visual observations and 2,000 photographs were made in the researches.

Liveing,* as the result of the work of Young, Dewar, Fievez and himself on the spectrum of the sun, by which some lines were resolved with a new instrument, which they before had not been able to devise, comments on Lockyer's work. That the coincidence of rays emitted by different chemical elements, especially when developed in the spark of a powerful induction coil, and the high temperature of the sun and stars, gives evidence of a common element in the composition of the metals which produce the coincident rays. "This result cannot fail to shake our belief, if we had any, in the existence of any common constituent in the chemical elements, but it does not touch the evidence which the spectroscope affords us that many of our elements, in the state in which we know them, may have a very complex molecular structure."

Hartley† in his recent admirable address said:

"I have always experienced great difficulty in accepting the view that because the spectrum of an element contained a line or lines in it which were coincident with a line or lines in another element, it was evidence of the dissociation of the elements into simpler forms of matter. In my opinion, evidence of the compound nature of the elements has never been obtained from the coincidence of a line or lines exclusively belonging to the spectrum of one element with a line or lines in the spectrum exclusively belonging to another element. This view is based upon the following grounds: First, because the coincidences have generally been shown to be only apparent, and have never been proved to be real; secondly, because the great difficulty of obtaining one kind

*Address before the Chemical Section of the British Association, Scientific American Supplement, 14, 356, 1882.

†*Loc. cit.*

of matter entirely free from every other kind of matter is so great that where coincident lines occur in the spectra of what have been believed to be elementary substances, they have been shown from time to time to be caused by traces of foreign matter, such as by chemists are commonly termed impurities; thirdly, no instance has ever been recorded of any homologous group of lines belonging to one element occurring in the spectrum of another, except and alone where the one has been shown to constitute an impurity in the other; as, for instance, where the triplet of zinc is found in cadmium and the triplet of cadmium in zinc, the three strongest lines in the quintuple group of magnesium is graphite, and so on. The latest elucidation of the cause of coincidence of this kind arises out of a tabulated record from the wave-length measurements of about three thousand lines in the spectra of sixteen elements made by Adeney and myself. The instances where lines appeared to coincide were extremely rare; but there was one remarkable case of a group of lines in the spectrum of copper which appeared to be common to tellurium; also lines in indium, tin, antimony, and bismuth, which seemed to have an origin in common with those of tellurium."

The last sentence presents the point I wish to emphasize. Tellurium has long obtruded itself before a satisfactory vision of the natural system. The table (given below) alone recites not a few efforts to obtain the contaminating constituent of tellurium which *à priori* is present from Hartley's observations (see also Grünwald, 1889, Table). The fractionation of a rubidium-cæsium mixture, perhaps, is a simpler problem than that confronting Pellini,* who reports a definite amount of an element with a high atomic weight (about 214) similar to and associated with tellurium.

What has been said applies especially to the elements of the rare earth class—"asteriods of the terrestrial family"—as phrased by Crookes. Many of them have not been secured

*Gaz. Chim. ital. 33, 11, 35.

with sufficient purity to claim an inherent spectrum; further, the spectra attributed have not been obtained under uniform conditions.

I have referred* somewhat in detail elsewhere to the factors producing variations in the absorption, as well as the advantages and disadvantages of the phosphorescent and reversal spectra.

Without doubt the spectroscopic criteria are the most valuable we have in judging finally the elements, and, mayhap, will remain so; but in my humble opinion such have not alone sufficient authority, as yet, to usher the aspirant to a place among the elect. The contention frames itself, however, in an expression of the need for uniformity.

Whether we follow the most advanced metaphysico-chemical teachings or no, if there be any one concept upon which modern practical chemical thought depends it is the law of definiteness of composition. There may be, and doubtless are, definite, perhaps invariable, properties of our elements other than their combining proportions, the atomic weights, if you please, yet, as far as we know, they approximate more closely than any fixed, if not permanent, ratios. Many of these values, by which we lay such store, are dependent upon data† in which, I venture the assertion, too great confidence has been bestowed, or opinions to which sufficient attention has not been given.

Although in this connection we shall give little heed to the suggested variability of the relative values, it may be remarked that Boutlerow, noting the variations observed in 1880 by Schützenberger, who, by the use of different atomic weights, obtained analyses summing 101 instead of 100, expressed the opinion that the chemical value of a constant weight, or rather mass of an element, may vary; that the so-called atomic weight of an element may be simply the carrier

*The Rare Earth Crusade, *loc. cit.*

†Others have been referred to in the address to which this is a sequel. *Loc. cit.*

of a certain amount of chemical energy which is variable within narrow limits (see also Crookes). Wurtz's summary of Boutlerow's views, at a meeting of the Chemical Society of Paris, provoked an interesting discussion. Cooke later published a statement that he had expressed similar views more than twenty-five years before. That is, in 1855 he had questioned the absolute character of the law of definite proportions and had suggested that the variability was occasioned by the very weak affinity between elements manifesting a fluctuating composition. Without doubt "The Possible Significance of Changing Atomic Volume,"* in which a suggestion as to the probable source of the heat of chemical combination is put forward by T. W. Richards, bears directly upon this phase of the problem.

While the atomic mass values depend directly upon the ratio between the constituents of the compounds, they rest equally upon the molecular weights. Many of the latter attributed to salts of some of the rare earths depend solely upon the specific† heat determinations of Hillebrand and Norton,‡ Nilson and Pettersson,§ who, in the light of subsequent investigations, we know worked with complexes. To be sure, those elements, which were apparently exceptions to the law of Dulong and Petit, possess low atomic weights (beryllium, boron, carbon, silicon, aluminum and sulphur), and have for the most part been brought into harmony. "The specific heats of all substances vary with the temperature at which they are measured, and though the variation is often slight, it is occasionally of relatively great dimensions. When this is so in the case of an element the question arises: At what temperature must the measurement of the specific heat be made in order to get numbers comparable with those of the other elements? No definite answer has been given to

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*Proc. Am. Acad. Arts and Sciences, 27, 1 (1901), and 27, 399 (1902).

†Berichte, 13, 1461 (1880).

‡Pogg. Annal., 156, and following.

§Berichte, 13, 146 (1880).

this question, but it is found that as the temperature rises the specific heat seems to approach a limiting value, and this value is not in general far removed from that which would make the atomic heat approximately equal 6.4."* In view of this, allotropism and the work of Richards adverted to, it appears that a revision of the specific heat values now taken is necessary before we can accept fully this law which has been most helpful.

Time will not admit of detailed statements, and it is unnecessary in this presence to more than call attention to the fact that what has been said is not applicable to each specific case. "*La critique est facile, mais l'art est difficile,*" as Berthelot† has said, yet we must appreciate that all our laws have their limitations. "Man being servant and interpreter of nature, can do and understand so much and so much only, as he has observed in fact or in thought in the course of nature. Beyond this he neither knows anything nor can do anything."‡

A glance at the extensive, even censored, list of claimants will evoke serious thought. "Thus was the building left ridiculous."§ The difficulties briefly outlined and the causes for lack in uniformity, are by no means insurmountable, but will continue until more systematic direction and prosecution of the work come about. Investigators in pure chemistry, as a rule, hold professorships, or other positions making equal demand upon their time. Furthermore, it is extremely rare that one man can become a master of the various delicate operations hinted at. Mallet‖ made a proposition for systematizing atomic weight work, and F. W.

*"Introduction to Physical Chemistry," James Walker, London. p. 33.

†"Les Origines de l'Alchimie," Paris, 1885.

‡Bacon's *Novum Organum*, Aphorism I.

§Milton, "Tower of Babel."

‖Stas Memorial Lecture, Chemical Society (London), delivered December 13, 1892.

Clarke in this country* and abroad† has urged the establishment of an institute for its prosecution. This appeals to all interested in what we are pleased to term the exact sciences, and doubtless in time will come about. For the time being, however, it is not unreasonable to suppose that a concerted appeal of the chemists of this country to the direction of the munificent endowment recently made American Science for funds to clarify the elemental enigma presented above would not be in vain. There are splendidly equipped chemical departments in some of our great American universities which would make room for, and cordially welcome, I am sure, a selected corps of supported researchers, who would test the claims of each of these and other elemental aspirants. Such a community of effort should receive even greater substantial assistance from governments and corporations than has been accorded individuals. I need only refer to the aid given the Curies by the Austrian government and generosity shown by the Welsbach Lighting Company in this country to several investigators, especially myself.

It must be evident to all that we are not indulging in special pleading, for every phase of that division of science designated chemistry rests upon what we choose to term the elements.

Victor Meyer‡ referring to the phantasies of science, said: "He, however, who only knows chemistry as a tradition of perfectly clear facts, or who thinks to see the real soul of chemical study in measuring physical phenomena which accompany chemical transformations, feels no breath of this enjoyment." Reflecting upon the good and ill that have come to us through unrestrained imagination, we may give a careful acceptance of Newton's "Physics, beware of metaphysics," for as Clifford wrote, "Doubtless there shall by

*Presidential Address before the American Chemical Society.

†Wilde Lecture at the Dalton Centenary, Manchester, 1903.

‡Lecture on "The Chemical Problems of To-day," before the Association of German Naturalists and Physicians at Heidelberg, September, 1889; Chemical News, 61, 21.

and by be laws as far transcending those we know as they do the simplest observations."

The graphic representation of the elements, "the foundation stones of the material universe which amid the wreck of composite matter remained unbroken and unworn," as Maxwell gracefully spoke of them, has often been mistaken for the periodic law. Carnelley's "reasonable explanations" of the periodic law were given a respectful hearing and forgotten.*

"Granting that the chemical characteristics of an element are connected with its atomic weight, we have, however, no right to assume them to be dependent upon that fact alone." (Liveing). Hinrichs says weight and form,† concerning the latter of which I am ignorant. No doubt the pendulum lately has swung back toward Berzelian thought revivified by the like masters, Van't Hoff and Arrhenius.

Le Verrier predicted the planet Neptune and his predictions were verified. While all of Mendelejeff's predictions, specific and tacit, have not been verified, some have. Ramsay,‡ and others without a periodic guide, predicted certain of the inert gases, which predictions have been verified.

Victor Meyer, in speaking of the completion of the Mendelejeff table, calls attention to the summing up of one hundred elements, from which it appears that 258 would be the limit to our atomic mass equivalents. I am not prepared to positively contradict such a conclusion at the present time, but there are reasons for thinking otherwise.

Clarke§ has shown that the mean density of the earth, 5.5

*He regarded the elements as compounds of carbon and æther analogous to the hydrocarbon radicals, and suggested that all known bodies are made up of three primary elements—carbon, hydrogen and æther; truly an assumption which cannot be disproved. Aberdeen Meeting, British Association.

†Atom Mechanics, Hinrichs, Vol. I, St. Louis, 1894, p. 242.

‡Address before the Chemical Section, British Association, Toronto Meeting (1898).

§"The Relative Abundance of the Chemical Elements," F. W. Clarke. Read before the Philosophical Society of Washington, Oct. 26, 1899; Chem. News, 62, 31.

to 5.6, is more than double that of the rocky crust, and "the difference may be accounted for as a result of pressure, or by supposing that, as the globe cooled, the heavier elements accumulated towards the center." While it is quite impossible to judge of the order of this intramundane pressure, I am not aware of such marked changes being brought about in the specific gravities of the heavier solid elements or their compounds either by pressure, allotropic or isomeric changes, except the cerebral argentaurum of the late S. H. Emmens.* The examinations of volcanic dusts by Hartley,† Fleet‡ and others appear to contradict the latter explanation, although we are unable to state the depth, perhaps within the shell, considered by Clarke, at which volcanoes begin their boisterous activity. While awaiting a fulfilment of Martinez's§ project to explore the earth's center, we may offer a third solution, not wholly unscientific, as it can do no harm, and has naught to do with any yellow peril in science, namely, the existence of elements with atomic weights higher than those set by the silent limit of periodic tables.

"Most molecules—probably all—are wrecked by intense heat, or in other words, by intense vibratory motion, and many are wrecked by a very impure heat of the proper quality. Indeed, a weak force, which bears a considerable relation to the construction of the molecule, can, by timely savings and accumulation, accomplish what a strong force out of relation fails to achieve."‖

As hinted at in the earlier portion of this unduly prolonged address, many have theorized as to the ultimate composition of matter. The logic of Larmor's¶ theory, involving the idea of an ionic substratum of matter, the sup-

*Argentaurum papers published by Emmens, New York.

†Royal Society, Feby. 21, 1901; Chem. News, 83, 174.

‡Abstr. Proc. Geol. Soc. 1902, 117. Journ. Chem. Soc. (Land) 81-82, ii, 518 (1902).

§La Nature, Sc. Am. Sup., 21, 546 (1886).

‖Tyndall in Longman's Magazine.

¶Phil. Mag., December, 1897, 506.

port of J. J. Thomson's* experiments, the confirmation of Zeeman's phenomenon, the emanations of Rutherford, Martin's† explanations, cannot fail to cause credence in the correctness of Crooke's idea of a fourth state of matter.‡ In the inaugural address as President of the British Association (1898), he acknowledges in the mechanical construction of the Roentgen ray tubes a suggestion by Silvanus Thompson to use for the anti-cathode a metal of high atomic weight. Osmium and iridium were used, thorium tried and in 1896 Crookes obtained better results with metallic uranium than platinum.

These and the facts that most of the elements with high atomic weights, in fact all above 200 (thallium not reported on),§ exhibit radio-active properties, are doubtless closely associated and have to do with the eventual composition of matter. I have unverified observations which go to show the existence of at least one element with a very high atomic weight. If it be confirmed, then we have them now or they are making, and probably breaking up, as shown by that marvellous class of elements in the discovery of which the Curies have been pioneers.

If our ideas, that all known elements come from some primordial material, be true, then it stands to reason that we are coming in time, perhaps, to that fixed thing, a frozen ether, the fifth state of matter. I may make use of dangerous analogy and liken our known elements, arranged in a perfected, natural system, as the visible material spectrum, while electrons, etc., constitute the ultra-violet and *cosmyle* composes the infra-red, either one of the latter by proper conditions being convertible into perceptible elemental matter. No positive evidence supports these ideas, but I like to fancy

*Phil. Mag., October, 1897, 312.

†Chem. News, 85, 205 (1902).

‡Phil. Trans. II (188), 433.

§See the exquisite paper by Madame Curie on "Radio-active Substances;" also "Radio-active Lead," Hofmann and Strauss, Berichte, 34, 3033, Pellini (*loc. cit.*) on "Radio-active Tellurium," Strutt, Phil. Mag., 6, 113, Elster and Geitle, Giesel, Marckwald, etc., etc.

scientific endeavor as the sea, calm and serene, supporting and mirroring that which is below it, bearing that which is upon it, reaching to and reflecting that which is above it, moving all the while; yet, torn and rent at times by conflict from without and contest within, it runs; it beats against the shores of the unknown, making rapid progress here, meeting stubborn resistance there, compassing it, to destroy but to rebuild elsewhere; and the existence of those within it! "Like that of Paul, our life should be a consecrated unrest."

PROPOSED CHEMICAL ELEMENTS.

Date.	Name of Element.	Source.	Authority.	References.	Remarks.
1777	*Terra Nobilis*..	Diamonds.....	Tobern Bergmann.		
1778	MOLYBDENUM...	Lead ores.....	Scheele.......	Kong. Vet. Acad. Handl. 247.	Molybdena meant number of substances carrying lead. Hjelm [(Ann. de Chim. 4, 17 (1790)], isolated the element.
1780	*Hydrosiderum*..	Cold short iron	Meyer	Schrift. Ges. Nat. Freunde, Berlin, II 334, & III 380.	*Wassereisen* obtained by dissolving crude iron in acids.(?) Klaproth proved it to be iron phosphide.
1781	TUNGSTEN......	Scheelite	Scheele.......	Kong. Vet. Acad. Handl. 89.	Acid separated from scheelite. Bros. D'Elhujar proved it in wolframite. The two minerals had been long known.
1781	*Siderum*........	Cold short iron	Bergmann....	....	Proved to be iron phosphide.
1782 (1798)	TELLURIUM.....	Native........	von Reichenstein & Klaproth.	Crell's Ann. 1, 91 (1798)	Regarded *aurum paradoxum* or *metallum problematicum*, and still is.
1784	Saturnum.......	Lead ore......	Monnet........	Journ. de Physique, 28.	

1788	*Diamanthspatherde.*	Corundum	Klaproth	Berchüft Ges. Nat. Freunde, Berlin, 8, 4.	Composed of silicon, iron, and aluminum oxides.
1789	URANIUM	Pitchblende	Klaproth	Crell's Ann. 2, 387.	Metal not separated until 1842, then by Péligot (Ann. de Chim. 5, 5).
1789	ZIRCONIUM	Zircon	Klaproth	Klaproth's Beiträge 1, 203; Crell's Ann. 1, 7. Ann. de Chim. 1, 238.	See work of Berlin (1860).
1790	*Australium* or Sydneium.	Sand	Wedgewood	....	Hatchett showed this Australian sand to contain iron, aluminum, and silicon oxides.
1791	*Menachite*	Magnetic sand.	McGregor	Crell's Ann. 1, 40, 103.	Klaproth four years later discovered titanium (Beitr. 1, 233), and in 1797 found it to be identical with Menachite (Beitr. 2, 236).
1794	YTTRIUM	Gadolinite	Gadolin	Sv. Vet. Akad. Handl. 1794, 137, and Crell's Annalen (1796) 1, 313.	Named by Ekeberg [Crell's Ann, 2, 63 (1799)].
1799	*Nameless earth.*	....	Fernandez	Scherer's Allg. J.	

PROPOSED CHEMICAL ELEMENTS—Continued.

Date.	Name of Element.	Source.	Authority.	References.	Remarks.
1800	*Augusterde*	Beryl.........	Trommsdorff..	Scherer's Allg. J. 4, 312 & Gehlen's Allg. J. 1, 445.	Vauquelin showed it to be calcium phosphate, now known as the mineral apatite.
1800	*Andronia*.......	Charcoal and saltpeter.	Wissterl......	Gehlen's J. & Gilbert's Annalen.	Committee of French Academy showed it to be composed of lime, alumina, silica and iron oxide.
1800	*Thelike*........	Marble.......	Wissterl.		
1801	*Alkali pneum*...	Borax........	Hahnemann ..	....	Proved to be borax.
1801	*Erythronium*...	Lead ore	Del Rio......	Ann. der Phys. u. Chem. 71, 7.	Because became red when heated with acids. Later Descotils and del Rio concluded it was impure chromium oxide (Ann. de Chim. 53, 268). (See Vanadium.)
1801 (1844)	COLUMBIUM (niobium).	Columbite.....	Hatchett (Rose).	Crell's Ann. 1, 197, 257, 352 (1802).	After Wollaston [Phil. Trans. 99, 246 (1809)] had said columbium and tantalum were same and it was accepted, effective work was done by H. Rose (Pogg. Ann. 70, 572; 71, 159, and many later) who renamed it niobium.

1802 (1844)	TANTALUM	Finnish tantalite and Yttrotantalite.	Ekeberg	Scheerer's J. 9. 547; Crell's Annalen 1803, 1.	Important work on this element also done by Berzelius (Pogg. Ann. 4. 6) and H. Rose (Pogg. Ann. 15, 145, etc.). (See Columbium.)
1803	Silene		Proust	Jour. de Physique.	
1804	CERIUM	Cerite and Ochroiterde.	Berzelius and Hesinger & Klaproth.	Gehlen's Ann. 2, 303 & 2, 397.	This complex later shown to contain lanthanum, but the name remains for the element.
1805	*Niccolanum*	Cobalt ores	Richter	Gilb. Ann. 19, 377.	Shown to be mixture of nickel, cobalt, arsenic, and iron.
1811	*Junonium*		Thomson	Phil. Mag. 36, 278 and Gilb. Ann. 44, 113.	Identity with cerium proved by Wollaston. (See Brauner's meta-cerium.)
1817	*Thorine*	Gadolinite	Berzelius	Afhandl. i Physik, Kemi Och Min. V, 76, and Ann. Chim. Phys. 5, 8.	Berzelius later [K. Vet. Acad. Handl. II, 4 (1824)] proved this to be yttrium phosphate.
1818	*Vestium* or Sirium.	Nickel ore	Vest	Gilb. Ann. 59 & 62.	Faraday showed it to be a mixture of nickel, iron, sulphur, and arsenic.
1818	*Wodanium*	Cobalt ore	Lampadius	Gilb. Ann. 60 & 64.	Stromeyer showed it consisted of nickel, arsenic, etc. *Wodankies*, present mineral Gersdorffite.

PROPOSED CHEMICAL ELEMENTS—Continued.

Date.	Name of Element.	Source.	Authority.	References.	Remarks.
1820	*Crodonium*	Sulphuric acid incrustation.	Trommsdorff.	Gilb. Ann. 65 & 66.	Discoverer afterwards demonstrated it to be mainly calcium and magnesium salts with copper and iron impurities.
1820	*Aurum Millium*	....	Mills.		
1821	*Apyre*	....	Brugnatelli	Gilb. Ann. 67.	
1828	THORIUM	Thorite	Berzelius	K. Sv. Ver. Akad. Handl. 1. Ann. d. Phys. 16, 385.	While no doubt a definite element as accepted, there is no question as to its complexity (see Chroustschoff, Schmidt, Curie, Rutherford, Brauner, and Baskerville).
1828	*Ruthenium*	Platinum ore (Urals).	Osann	Pogg. Ann. 14, 340.	Not to be confounded with well-known rutherium of Claus. Said to be metal of golden luster. Osann previously (Pogg. Ann. 13, 287) gave the name to reddish, volatile prisms pronounced by Berzelius new (*vide* Howe's vice-presidential address before this Section, 1900, 92).

1828	*Pluranium*....	Platinum ore (Urals).	Osann........	Pogg. Ann. 14, 340.	Shown to be a mixture of oxides of titanium, zirconium, and silicon by Osann [Ann. der Phys. (Pogg.) 15, 158 (1829)].
1828	*Polinium*.......	Platinum ore (Urals).	Osann........	Pogg. Ann. 14, 340.	Proved to be impure iridium by the discoverer.
1830	VANADIUM......	Swedish iron ore.	Sefström......	Am. J. Sc. [1], 20, 386.	About same time Wöhler showed identity of this with erythronium (Pogg. Ann. 21, 49).
1836	*Donium*........	Aberdeen mineral.	Richardson.. .	Ann. Chem. Pharm. 19 and 23.	Identical with glucinum, as shown by Heddle.
1836	*Treenium*......	....	Boase.........	Thomson's Records Gen. Science 4, 20.	Identical with donium.
1839	LANTHANUM....	Ceria.........	Mosander.....	Pogg. Ann. 46, 648, & 47, 207.	Separated by action of very dilute acid.
1842	*Didymium*.....	Lanthana.....	Mosander.....	Ann. Chem. (Liebig) 44, 125 & 48, 210.	Doubted by Hermann [J. prakt. Chem. 34, 182 (1845)]. Shown to contain samarium; later split into neo- and præseodidymium by Auer (Monats. 6, 477), Delafontaine [Compt. rend. 87, 634 (1878)] had written on the probable compound nature. Krüss and

PROPOSED CHEMICAL ELEMENTS—Continued.

Date.	Name of Element.	Source.	Authority.	References.	Remarks.
					Nilson [Chem. News 56, 166 (1887)] from study of absorption spectrum maintained composed of nine elements. See papers by Baskerville for summary of spirited controversy as to this by numerous workers.
1843	Terbium	With erbium in gadolinite.	Mosander	Ann. Chem. Pharm. 68, 131, 137, etc.	Mosander separated yttria into basic yttria, least basic erbia, and intermediate terbia. Shown by Berlin (1860) to have no existence, although Mosander's results were confirmed by Berzelius ("Lehrbuch" 2d French edition, 2, 163), Svanberg and Scheerer. Berlin did obtain rose-colored salts of terbia since called erbium, but Mosander's yellow erbia, the present terbia, he did not secure [Scand. Naturf. 8 möde Kjöbenham, p. 448 (1860)]. Verified by Delafontaine, Bahr and Bunsen [Liebig's Ann. 137 (1866)], and Cleve and Högland [Bull. Soc. Chim. (2), 18, 193, 289 (1872)].
1843	Erbium	With erbium in gadolinite.	Mosander	Ann. Chem. Pharm. 68, 131, 137, etc.	

1845	*Norium*	Zirconia	Svanberg	Oefvers. K. Vet. Akad. Förhl. 1845, 34; Ann. (Pogg.) 65, 317; Am. J. Sci. (2) 1, 257; Berg. Jahre esb. prakt. Chem. 57 and 97.	Reason for assuming existence "great variation in atomic weight of oxide." Denied by Berlin (J. prakt. Chem. 58, 145). Also Marignac (Compt. rend. 50, 952; Chem. Centr. bl., 1860, 603). Proved identical with zirconium by Herrman (J. prakt. Chem. 97, 330; Job, 1866, 189). Taken back by Svanberg (J. pr. Chem. 58, 145).
1846	*Pelopium*	Bavarian tantalate.	H. Rose	Pogg. Ann. 69 & 90. Chem. Gaz. 1846, Sept. 5, Am. J. Sci. (2), 3, 357.	Discoverer later showed pelopic acid was convertible into columbic and hypocolumbic acid.
1846	*Ilmenium*	Ilmenite	Hermann	Journ. prakt. Chem. 38 & 40, Pogg. Ann. 73.	Proved to be columbium.
1850	*Aridium*		Ullgren	Journ. prakt. Chem. 52, Ann. Ch. Pharm. 76 and 78.	Proved to be composed of iron, chromium and phosphoric oxides (1854).
1851	*Donarium*		Bergmann	Ann. Ch. Pharm. 80 and 84.	Proved to be thorium (1863).
1852	*Thalium*		Owen	Am. J. Sci. (2) 13, 11, 17.	

PROPOSED CHEMICAL ELEMENTS—Continued.

Date.	Name of Element.	Source.	Authority.	References.	Remarks.
1852	Unnamed	Gold ores. (Calif.)	Genth	Proc. Acad. Sc. Phil. 9, 209, Am. J. Sc. (2), 15, 446 (1853).	Two grains white metal platinum from California gold with properties unlike those of any known element.
1854	*Nameless Earth.*	Zirconia	Sjögren	Journ. prakt. Chem. 55 and 57.	Precipitation by potassium ferrocyanide. Specific gravity *oxide* 5.5 *instead of* 4.3.
1860	Cæsium	Alkaline Salts.	Bunsen & Kirchoff.	Pogg. Ann. 113, 337; Chem. News, 11, 281.	Setterberg obtained metallic cæsium by electrolysis in 1881.
1860	*Dianum*	Finnish tantalate.	von Kobell	Am. Ch. Pharm. 114, & 136; Journ. prakt. Chem. 83, 193, 449.	Identity questioned by H. Rose, St. Claire Deville, and Hermann. Gives deep blue color with tin and hydrochloric acid. Marignac and Blomstrand proved it to be columbium (1865).
1861	Rubidium	Lepidolite	Bunsen & Kirchoff.	Jsb. 173; Chem. News, 11, 357.	Berketoff prepared rubidium by heating hydroxide with aluminum (1888).

1861	*Nameless Earth.*	Calcium group.	Dupré.		
1861	THALLIUM......	Selenium residues.	Crookes......	Chem. News, 111, 194.	Brilliant green line in spectrum. Lamy (Ann. Chim. Phys. [3], 67, 385) announced same element about same time.
1862	Unnamed.......	Native platinum (Oregon).	C. F. Chandler	Am. J. Sc. (2), 32, 351.	Probably same as that discovered by Genth as pointed out by Chandler.
1862	*Wasium*........	Wasite.......	Bahr.........	Pogg. Ann. 119, 572, Journ. prakt. Chem., 91, 316.	Nicklé's showed it to contain yttrium, terbium and didymium (Comp. rend. 57, 1740). Delafontaine maintained it to be cerium oxide, while Popp contended it was mixture of oxides of yttrium, cerium and didymium (Ann. der Chem. und Pharm. 131, 364, 568.)
1863	INDIUM.........	Lead, zinc, & arsenic ores.	Reich and Richter.	J. prakt. Chem. 89, 441.	Blue line (hence named) found in spectrum when looking for thallium.
1863	A new earth....	Calcareous mineral.	Bischoff......	Pogg. Ann. 122, 646; Am. J. Sci. (2) 38, 420 (1864).	Forms characteristic volatile chloride, which is soluble in water precipitated by bases. This dissolves in hydrochloric acid, forming the chloride, which sublimes easily. Not verified.

PROPOSED CHEMICAL ELEMENTS—Continued.

Date.	Name of Element.	Source.	Authority.	References.	Remarks.
1864	*Nameless Earth*.	Zirconia......	Nylander......	Actr. Univers. Lundensi. 1864.	Solubility of double potassium sulphates.
1866	Nigrium........	Zirconia......	Church	Chem. News, 1869...	Black absorption bands of spectrum.
1867 (1898)	Aurorium....... Nebulium.	Aurora	Angström	Nov. Acta. Upsala, Sci. [3] 9, 29.	"Still awaiting discovery by more fortunate spectroscopists are the unknown celestial elements, aurorium, with a characteristic line at 5,507.7, and nebulium, having two bright lines at 5,007.05 and 4,955.02." (Crookes, 1898.) See Huggins (Roy. Soc. 1889; Chem. News, 59, 161) with account of observations in 1874.
1868 (1895)	Helium........	Sun's Chromosphere, Cleveite.	Jannson, Lockyer, Ramsay.	....	D_3 line charactertistic in this celestial and terrestrial element, doubtless had by Palmieri (1882) from lava and Hillebrand from uranium minerals. Ramsay secured it and described its properties definitely however (1895).

1869	*Jargonium*......	Zirconia.......	Sorby.........	Proc. Roy. Soc. 17, 511; Chem. News 19, 121, 142, 181; Berichte 2, 126, 193, 337, 382.	Absorption bands in spectrum. Insoluble tartrate in tartaric acid. Solubility chloride in hydrochloric acid.
1869	*Nameless Earth*.	Zirconia.......	Loew	Annals N. Y. Lyc. Nat. Hist. 9, 211.	Variation in nature of sulphates. Solubility oxide in oxalic acid.
1875	GALLIUM........	Zinc blende....	de Boisbaudran.	Compt. rend. 81, 493; Chem. News, 32, 159.	Found by spectroscope; in very small amounts, but widespread, as shown by Hartley and Ramage. Quite true of most elements (see Gautier on hydrogen and arsenic; Baskerville on titanium and others).
1877	*Davyum*	Platinum residues.	Kern..........	Chem. News 36 (4, 92, 14, 155, 164) and 37, 65.	Shown by Mallet [Am. Ch. J. 20, 776 (1898)] to be a mixture of iridium, rhodium and iron.
1877	Neptunium......	Columbite and ferroilmenite.	Hermann.....	J. prakt. Chem., 2, XV, 105, C. N. XXXV, 197.	Separated by difference in solubility of double potassium fluorides.
1877	*Mosandrum*....	Samarskite	J. L. Smith...	Letter No. 14 in Am. J. Sci. (3), 14, 509; Proc. Acad. Nat. Sci., Phila.,	Due to insolubility of double potassium sulphate. Marignac (Compt. rend. 87, 281) proved it identical with terbium. Also by Delafontaine (Compt.

PROPOSED CHEMICAL ELEMENTS—Continued.

Date.	Name of Element.	Source.	Authority.	References.	Remarks.
				29, 194; Compt. rend. 87, 148; C. N. 38, 100.	rend. 87, 600). de Boisbaudran finally (*loc. cit.* 102, 647) demonstrated it to be mixture of didymium, samarium, gadolinium and terbium.
1877	Lavoesium.......	Pyrite.........	Prat..........	Le Monde pharmaceutique.	
1878	"New earths"..	Unnamed mineral.	Gerland.......	C. N. 38, 136.	
1878	"X"..........	Gadolinite....	Soret.........	Compt. rend. 88, 1062.	Identical with Holmium subsequently discovered by Cleve, giving bands λ 640 and 536.3 with λ 451.5 and 753.
1878	*Philippium*....	Samarskite....	Delafontaine..	Compt. rend. 87, 559, and Chem. News 36, 202.	More soluble formate. Characterized by absorption. λ 450 (dysprosium in Soret's "X.") Roscoe [Ber. 75, 1274 (1882)] showed it in a mixture of terbia and yttria. Also denied by Crookes (Phil. Trans. 174, 910) and Urbain (Ann. Chim. phys. (7), 19, 192 (1900).

1878	*Decipium*......	Samarskite....	Delafontaine..	Compt. rend. 87, 632, and Chem. News 38, 223.	Absorption bands λ 416 and λ 478—one now belonging to samarium of de Boisbaudran—would be decipium now, but Delafontaine said his had *no* absorption bands.
1878	YTTERBIUM.....	Gadolinite....	Marignac.....	Compt. rend. 87, 578, and Chem. News 38, 213.	While trying to isolate Delafontaine's philippium.
1879	SCANDIUM......	Gadolinite....	Nilson........	Compt. rend. 88, 645; Chem. News 40, 76; Ber. 12, 554, 13, 1439.	Definite spark spectrum (Thalen, compt. rend. 88, 646; 81, 451; Chem. News 47, 217). In verifying Marignac's work on ytterbium.
1879	Norwegium.....	Gersdorffite...	Dahll........	Zeits. d. geol. Gesells 31, 480; Compt. rend. 89, 47; Chem. News 40, 25.	Atomic weight ascribed 145.9. Not enough had for work. Mendelejeff hoped it might prove to be eka-cadmium. Brauner suggested Ng = 219. Not proven.
1879	SAMARIUM......	Samarskite....	de Boisbaudran	Compt. rend. 88, 322; Chem. News 40, 99.	Delafontaine's original decipium. Demarcay separated europium from it.
1879	*Barcenium*.....	....	....	Wagner's Jahresbericht Jsb. chem. Tech. 1879, 8.	Misapprehension.

PROPOSED CHEMICAL ELEMENTS—Continued.

DATE.	NAME OF ELEMENT.	SOURCE.	AUTHORITY.	REFERENCES.	REMARKS.
1879	THULIUM.......	Gadolinite....	Cleve	Compt. rend. 89, 478.	In examining Mosander's erbia.
1879	Holmium.......	Gadolinite....	Cleve	Comp. rend. 89, 478.	Admitted by Cleve to be Soret's "X." Subsequently found by de Boisbaudran to be a mixture of true Holmium and dysprosium [Comp. rend. 102, 1003 (1886)]. Crookes says only one of the several bands, 451.5, belongs to dysprosia.
1879	Ouralium.......	Russian platinum.	Guyard.......	Monit. Scient. (3) 9, 795; Chem. News 40, 57.	Resembles platinum but softer; atomic weight 187.5. Gives orange melt with potassium cyanide. Unverified.
1879	Columbium.....	Samarskite....	J. L. Smith...	Nature 21, 146	Not to be mistaken for Columbium (Niobium).
1879	Rogerium.......	Samarskite....	J. L. Smith.		
1879	*Vesbium*.......	Lava (Vesuvius).	Scacchi.......	Chem. News 41, 116.	Proved to be Vanadium oxide. *Vide* Rammelsberg [Ber. 13,250 (1880)].
1880	Comesium.. ...	....	Kaemmerer....	Chem. Zeit. 1880, 273.	

1880 (1886)	Yα — GADOLINIUM.	Samarskite....	Marignac	Arch. des. Sci. phys. et nat. (3), 3, 413;	These later proved to be complex, but definite elements by the second names had from them. Delafontaine decomposed didymium, which proved to be identical with Y β Delafontaine's original decipium.
1880 (1885)	Yβ — SAMARIUM	Samarskite....	Marignac Delafontaine.	Compt. rend. 104, April, No. 16.	
1881	*Actinium*	Zinc white.. .	Phipson......	Chem. News 44, 73, 138, 191.	Not to be mistaken for Debierne's Actinium.
1882	*Didymium β*....	Gadolinite ...	Cleve	Chem. News 45, 273.	
1883	Nameless.......	Platinum ores.	Wilm.........	Berichte 16, 1298.	
1884	Idunium........	Vanadium ore.	Websky.......	Sitzungsb. Ak. Wiss. (Berlin) 30, 661.	
1885	NEODIDYMIUM...	Didymium....	Auer.........	Monats. 6; Chem. News 52, 49.	"Meta-elements," no doubt of complexity. (See work of Krüss, Nilson, Kiesewetter, Brauner, Crookes, Bettendorff, Forshing, Thompson, Dennis, Boudouard and Baskerville.)
1885	PRÆSEODIDYMIUM.	Didymium....	Auer.........	Monats. 6; Chem. News 52, 49.	
1885	*Zα*............ *Zβ*............ *Zγ*............	Didymium....	de Boisbaudran	Compt. rend. 102, 153 and 1889; Chem. News 53, 63.	Identical with Crookes Gδ. Probably terbia, apparently identical with Crookes Gζ. See Crookes below.
1885	Unnamed.......	Cerite........	Brauner.	J. Chem. Soc. 47, 879.	Brauner (Monatshefte 3, 487) Didymium β and perhaps Didymium γ.

PROPOSED CHEMICAL ELEMENTS—Continued.

Date.	Name of Element.	Source.	Authority.	References.	Remarks.
1886	*Zγ*............	Terbia	de Boisbaudran	Compt. rend. 102, 153; Chem. News 53, 63.	By electric spectrum lines γ 583.5, 575, 570, 526.9.
1886	Dysprosium.....	Soret's "X" (Holmium).	de Boisbaudran	Compt. rend. 102, 1003.	Bands λ 451.5 and λ 752.
1886	Dysprosium X..	Dysprosium...	Crookes.......	Proc. Roy. Soc. 40, 502.	Having absorption band λ 451.5 only. Agreed to by de Boisbaudran. (See Holmium.)
1886	Unknown.......	....	Crookes.......	Proc. Roy. Soc. 40, 502.	Absorption bands 550 and 493 not in thulium, erbium, holmium and dysprosium.
1886	*Austrium*......	Orthite.......	Linnemann....	Nature, 34, 59; Monatsh. 1886, 773.	Orthite re-examined by Pribram (Monats. 21, 148, 1900), who confirms de Boisbaudran's [Compt. rend. 102, 1436 (1886)] that this "austrium" is identical with gallium.

1886	GERMANIUM....	Argyrodite....	Winkler......	Berichte 19, 210; Chem. News 54, 136.	As predicted by Mendelejeff.
1886	*Da*............	Didymium....			New.
1886	*Sβ*............	Samarskite....			New.
1886	*Sγ*............	Samarskite....			Ytterbium.
1886	*Gα*............	Gadolinite...			New.
1886	*Gβ*............	Gadolinite....	Crookes......	Chem. News 54, 13; Nature 34, 160.	Gadolinium or *Zβ*. [See de Boisbaudran (Compt. rend. 103, 114.)]
1886	*Gγ*............	Gadolinite....			New.
1886	*Gδ*............	Gadolinite....			New or *Zα*. (See de Boisbaudran.)
1886	*Gε*............	Gadolinite....			New.
1886	*Gζ*............	Gadolinite....			New.
1886	*Gα*............	Gadolinite....			New.
					Based upon radiant matter spectroscopy. Strongly opposed by de Boisbaudran (Chem. News 54, 15). Truly "a nebula of elementary matter" as Pettersson put it. See original for vacuum bands belonging to each.
1886	Polymnestrum...	Glacial débris in Scotland.	Pringle......	Chem. News 54, 167.	One must read the original to appreciate the wonderful properties of these elements of which we have heard nothing since their announcement. Considering these facts, the country of the discoverer and the *time* of the presentation of the paper (during the heat of the Crookes-de Boisbaudran controversy) without inside information, an American might appreciate a joke.
1886	Nameless (1)....				
1886	Erebodium......				
1886	Nameless (2)....				
1886	Gadenium.......				
1886	Hesperisium....				

PROPOSED CHEMICAL ELEMENTS—Continued.

Date.	Name of Element.	Source.	Authority.	References.	Remarks.
1887 1887 1887 1887 1887 1887 1887 1887	*Erα* .... *Erβ* .... *Tmα*........... *Tmβ*........... *Smα*........... *Smβ*. .... *Xα* to *Xη* (7) ... *Diα* to *Diκ* (10).	Erbia .... Erbia .... Thulia .... Thulia .... Samaria...... Samaria...... Soret's "X".. Didymia......	Krüss and Nilson, Kiesewetter and Krüss.	Berichte 20, 2134 and 21, 2310.	Lettered according to source; the Greek characters serve to show each one has one absorption line or band. This is an argument as to the complexity of those elements showing absorption spectra. A most careful study of these and other data offered by Schützenberger, Boudouard, Crookes, Brauner, Muthmann, Dennis, Baskerville and others enforces the "one band one element" idea of Crookes. Distinctly, however, so far the case is "not proven."
1887	Three unknown New Earths.	Didymium from Cerite.	Demarcay	Compt. rend. 102, 1552. Compt. rend. 104, 580. Compt. rend. 102, 1552.	Absorption band λ 475 in didymium spectrum (also Crookes Compt. rend. 102, 1551). Band λ 462 in old didymium spectrum; same giving rise to 475, belonging to samarium series according to Crookes (see). Absorption band λ 434 in old didymium spectrum.

1889	Russium........	Thorium from Monazite.	Chroustschoff..	Chem. Zeit; Chem. News 59, 234.	Meager information as to procedure to be had.
1889	*Austriacum*.....	Tellurium	Brauner.......	Trans. Chem. Soc. (Lond.) 407, 411; Monatsh. 10, 448.	Working on atomic weight of tellurium, Brauner thought he secured homologue, atomic weight 214. Later modified claims (J. Ch. Soc. 67, 549) stating homologue of argon. See Köthner [Annalen 319, 1 (1901)] Staudenmaier [Zeit. Anorg. Chem. 10, 189 (1895)] and Norris, Fay and Edgerly [Am. Chem. J. 23, 105 (1900)] concluded tellurium elementary. (See also Lenher.)
1889	Ekatellurium.....	Tellurium, Antimony and Copper.	Grünwald.....	Imperial Academy of Sciences, Vienna, 98, 2; Chem. News 61, 39.	Characteristic unknown element X in 11th series of Mendelejeff's table, related to tellurium on one hand and bismuth on other. Probable atomic weight 212 and identical with Brauner's Austriacum. Wave lengths of 16 rays observed in ultra-violet between 2769–2159. See Ames' remarks *re* Grünwald's helium and coronium conclusions.
1890	*Damarium*...........................		Much	Chem. Zeit. 1890	Good fun.

PROPOSED CHEMICAL ELEMENTS—Continued.

Date.	Name of Element.	Source.	Authority.	References.	Remarks.
1892	*Gnomium*......	Cobalt and nickel.	G. Krüss & F. W. Schmid.	Berichte, 22, 11 (1889) 22, 2026; Zeit. f. Anorg. Chem. 2, 235 (1902).	Disproved by Winkler [Zeit. Anorg. Chem. IV, 10 (1893)].
1892	Masrium........	Egyptian Johnsonite or Maserite.	....	Chem. Zeitung; Chem. News 65, 259.	Said to have atomic weight 228, apparently no need to confirm this (Crookes).
1892	*Zε*............	....	de Boisbaudran.	Compt. rend. 119, 575.	Follows samarium spark spectrum [see Europium (Compt. rend. 1469)].
1892	*Zζ*............	....	de Boisbaudran.	Compt. rend	Follows samarium reversion bands. Demarcay's Europium.
1893	*Probable Earth*.	Terbia	Hermann & G. Krüss.	Zeit. Anorg. Chem. 4, 27.	
1894	A new Element?	French bauxite	K. I. Boyer...	Chem. Zeit. 18, 671.	Based on some qualitative tests.

[illegible]	[illegible]	[illegible]	de Boisbaudran.	Compt. rend. 121, 709; Chem. News 72, 292.	Paper in sealed packet deposited with the French Academy. Beginning of Crookes-de Boisbaudran spirited controversy. Absorption band 487.7 does not belong to terbium or dysprosium.
1895	ARGON	Atmosphere	Rayleigh & Ramsay.	Roy. Soc. (London) Jan. 31, 1895.	Holds its own although numerous efforts have been made to show it to be allotropic nitrogen. Distinctly inert element. A hydrate has been suggested. Also separated by Cavendish. [Phil. Trans. 75, 372 (1785) and 78, 271 (1788)].
1895	*Par-Helium*	Helium	Runge & Pascher.	Math. nah. Mitt. (Berlin) 323.	Found lines in spectrum could be divided into two sets and each set consisted of a primary and two secondary series of lines. Later found change of pressure in tube will cause this change as with oxygen, for example.
1896	*Lucium*	Yttria from Monazite.	Barrière	Chem. News 74, 159, 212.	Shown to be a mixture of yttrium, didymium, erbium, and terbium by Crookes (Chem. News 74, 259) and Shapleigh (Chem. News 76, 41).

PROPOSED CHEMICAL ELEMENTS—Continued.

Date.	Name of Element.	Source.	Authority.	References.	Remarks.
1896	"Σ" or "$\Sigma - Z_\epsilon$."	Gadolinium & Samarium.	Demarcay.....	Compt. rend. 122. 728, and 32, 1484 (1900).	Extreme fractionation of double magnesium nitrate; atomic weight 151.5. Most characteristic ray, Crooke's anomalous $S\delta$ (fluorescent), and $Z\zeta$ of de Boisbaudran (reversion) spectrum [Compt. rend. 132, 148 (1901)]. See europium.
1895	Unnamed.......	Monazite......	Schützenberger & Boudouard	Compt. rend. 121, 273; 122, 697; 123, 782; 126, 1648.	Fractional fusion of nitrates and crystallization of sulphates obtained, atomic weight 124 (?). Urbain (Bull. Soc. Chem. Paris (3), 19, 38) states this is mixed with other rare earths. (See Lucium) also Nordenskjöld's "oxide of gadolinium" (Compt. rend. 103, 795).
1896	Kosmium....... Neokosmium.	....	Kosmann.....	Zeits. f. Elektrochemie 1896–'7.	Winkler remarks: "If it were not for the expense of the patent, it might have been thought a pleasantry" (Discovery of New Elements, etc., German Chemical Society, Jan. 11, 1897). But see Barrière's lucium.

1896	*Unnamed*	Monazite	Drossbach.....	Berichte 29, 15; 30, 2452.	Having worked up large amount of the by-products obtained in extracting thorium from monazite, obtained strongly basic earth, sulphates soluble in double alkaline sulphates. Atomic weight 100 (?). Boudouard and Schützenberger obtained one with 102. Urbain and Budischovsky (Compt. rend. 124, 618) fractioned these by acetylacetonate compounds in organic solvents into extremes giving values 95 and 112. Mixture. (See Lucium.)
1897	Metacerium.....	Cerium........	Brauner.......	Proc. Chem. Soc. No. 191, 69–70, and Chem. News 71.	By fractioning what was thought to be pure ceria, differences in specific gravity oxides, atomic weight, but no spark spectral differences. Perhaps has atomic weight 110, according to Brauner.
1897	Glaukodymium..	Didymium....	Chroustschoff.	J. Rus. Phys. Chem. Soc. 29, 206.	Distinguished from præseodidymium and neodidymium by blue color of salts. (See these elements. No doubt as to their complexity.)
1897	A possible New Element.	Cast Iron.....	Boucher......	Chem. News 76, 99.	See also Rubdock (Chem. News 76, 118). Thought to be Molybdenum by C. H. Jones (Chem. News 76, 171), but denied by Boucher.

PROPOSED CHEMICAL ELEMENTS—Continued.

Date.	Name of Element.	Source.	Authority.	References.	Remarks.
1898	Radio-active Thorium (Thorium X).	Pitchblende...	Curie and Schmidt (Independently.)	Wied. Ann. 65, 141, and Madame Curie's thesis, Faculté des Sciences de Paris (1903).	See also Crookes' thorium X and Rutherford's thorium X. All likely same. Characteristic "emanations," perhaps due to helium (see Soddy and Rutherford and Ramsay, Chem. News, 1903). Giesel (Ber. 34, 3776) says radio-activity not due to actinium.
1898	Coronium	Fumarole Gas.	Nasini, Anderlini, Salvadori.	Atti R. Acad. dei Lincei, Roma (5), 7, II, 73; Chem. News 78, 43.	Spectra of gases from Solfatara di Pozzuoli and Vesuvius fumaroles showed, besides argon, (531.5) and other lines, 1474 K attributed to the corona, hence terrestrial coronium.
1898	Krypton.......	Liquid air	Ramsay & Travers.	Proc. Roy. Soc. 63, 405.	See special works on these novel constituents of the air; also Ladenburg and Krügel.
1898	Neon...	Liquid air	Ramsay & Travers.	Proc. Roy. Soc. 63, 437.	Predicted by Johnstone Stoney from mathematical calculations and Ramsay (V. p. address Chemical Section, B. A., Toronto meeting, 1898).

1888	XENON	Liquid air	Ramsay & Travers.	Chem. News 78, 154.	Very heavy gas.
1898	*Metargon*	Liquid air	Ramsay & Travers.	....	Subsequently shown to be carbon monoxide by discoverers.
1898	Etherion	Air	Brush	Trans. Am. Ass. Adv. Sc. Boston Meeting; Chem. News 78, 197.	Calculated atomic weight 0.001 (H = 1). Crookes attributes the observations to watery vapor. A personal letter assures me he is still busy with the problem and "building a very large and elaborate apparatus for separating minute quantities of very light gases." (C. B.)
1898	Polonium	Pitchblende	Curies	Compt. rend. 127, 175 and 134, 85 (1902).	Radio-active bismuth. Precipitated by hydrogen sulphide from acid solution. See also Giesel [Wied. Ann. 69, 84 (1899)] and Marckwald (Berichte, 35, 2285 (1902)].
1898	RADIUM	Radio-active Barium in Pitchblende.	Curies	Compt. rend. 127, 1225; Compt. rend. 129, 717 (1899); Wied. Ann. 2, 742 (1900).	By prolonged fractional crystallization of chlorides and bromides. Characteristic spectrum as shown by Demarcay, Runge, and Exner and Crookes (Chem. News). For full account of this wonderful substance see Madame Curie's dissertation (Chem. News 88,

PROPOSED CHEMICAL ELEMENTS—Continued.

Date.	Name of Element.	Source.	Authority.	References.	Remarks.
					many numbers). "Ueber radioaktive Substanzen," Giesel; "Die Radioactiven Stoffe, etc.," Hofmann; "Radio-activity and Chemistry," Barker and numerous papers in the journals.
1899	Actinium	Pitchblende	Debierne	Compt. rend. 129, 593; 130, 906 (1900).	Resembles titanium in iron group. See full papers and work of Hofmann and Zerban [Berichte 35, 531 (1902)], Baskerville (J. Am. Ch. Soc. 23, 761) and Brauner, Proc. Chem. Soc. 17, 67). No doubt new element. Must not be confounded with Phipson's Actinium (see Uranium X).
1899	Asterium Hydrogen (new) Unknown.	Stars of different temperatures.	Lockyer	Roy. Soc., Feby. 23, 1899; Chem. News 79, 145 (1899).	Dependent upon spectroscope. See original paper for wave lengths and range of stars in which the several lines may be seen. See also Pickering's "new hydrogen."

1899	VICTORIUM (Monium).	Yttria	Crookes	Chem. News 79, 212; 80, 49.	First called "Monium." Atomic weight and spectrum criteria (also phosphorescent). Obtained by prolonged and varied fractionations of yttrium salts. Atomic weight 117.
1900	Uranium X	Uranium	Crookes	Proc. Roy. Soc. 66, 407.	Doubtless Debierne's actinium. Hofmann and Zerban (loc. cit.) maintain minerals freed from uranium give a non-active thorium. The whole problem of radio-activity is open. Strutt (Phil. Mag. (6) 6. 113) secured strong radio-active gas from mercury; Wilson [Prac. Phil. Soc. (Camb.) II, 85 (1903)] showed fresh snow gives radio-active residue on evaporation. Geigel [Ann. Physik (iv) 10, 429 (1903)], &c., &c.
1900	Thorium α Thorium β	Thorium	Brauner	Proc. J. Chem. Soc. London 17, 67.	Hydrolysis of hepta-hydrated thorium tetra-ammonium oxalate. One with atomic weight 220, other 260. No doubt one method, but slow at breaking thorium into its constitutents. (See Baskerville). Auer (Ch. News 85, 255, J. f. Gasbeleucht u Wasservers, 1901, 661) says quite possible thorium is not an element. Dross-

PROPOSED CHEMICAL ELEMENTS—Continued.

Date.	Name of Element.	Source.	Authority.	References.	Remarks.
					bach (Zeit. f. angew. Chem. 14, 655) analyzed two commercial thorium nitrates and found small amounts of different rare earths present. He accounts for Brauner's observations by the presence of ytterbium.
1900	Γ .... Δ .... Ω .... θ	Terbia	Demarcay	Compt. rend. 131 (6); Chem. News 82, 127.	Δ may be de Boisbaudran's $Z\gamma$. Characteristic spectral lines. Unsettled so far.
1900	Krypton II	Liquid air	Ladenburg & Krügel.	Akad. d. Wiss (Berlin) Chem. News. 82, 269.	850 litres liquid air distilled. Molecular weight obtained = 58.81.
1900	Austrium (II)...	Orthite	Pribram	Monats. 21-148-155 (1900) J. C. Soc. (L.) 77-S, 3, 347.	(See Linnemann). He found traces of a new element, quite distinct from Linnemann's; yet to be isolated.
1900	Carolinium......	Thorium	Baskerville....	Am. Chem. Soc. (N. C. Section) April, 1900. J. Am. Ch. Soc. 23, 761; Chem. News.	Independently of Brauner. Pure thorium fractioned by precipitation with sulphur dioxide, etc. Variation in atomic weights (225 for 232.6). Heavy constituent more radio-active

					than other; judged by photographic and electrical methods. Later work, fractioning by organic bases and distillation of chlorides. Show three elements present—carolinium, true thorium and berzelium (see). Doubtless Thorium X of Crookes and Rutherford is the radio-active element present accumulating with the carolinium. It does not necessarily follow that carolinium is radio-active, although the active body accumulates with it.
1900	Radioactive Lead	Bröggerite....	Hofmann and Strauss.	Berichte 33, 3129; and 34, 907; (1901) 35, 1453 (1902), etc.	Primarily active substance. They state perhaps two elements present with atomic weights 100.92 and 171.96.
1901	"Σ" EUROPIUM.	Samarskite....	Demarcay....	Compt. rend. 132, 1484.	Atomic weight 151, characteristics spark spectrum. Phosphorescent spectrum shows it to be Crookes Sδ and reversal spectrum de Boisbaudran's Sζ.
1901	*Euxenium earth* I.	Euxenite from Brevig.	Hofmann and Prandtl.	Berichte, 34, 1064.	Differs from zirconium in certain reactions, atomic weight 178 (circa) if it be tetra-valent. Also another unknown substance present giving chem-
1901	*Euxenium earth* II.	Euxenite from Brevig.	Hofmann and Prandtl.	Berichte, 34, 1064.	

PROPOSED CHEMICAL ELEMENTS—Continued.

Date.	Name of Element.	Source.	Authority.	References.	Remarks.
					ical reactions quite different from I. Giesow and Horkheimer [Zeit. Anorg. Ch. 32, 372 (1902)] failed to secure either from purchased pure zirconium sulphate.
1902	*Amarillium*.....	Copper ore (British Columbia).	Courtis.......	Trans. Am. Inst. Min. Eng. (Adv. Sheet) New Haven Meeting, October, 1903.	In parting gold button observed peculiar behavior. Hillebrand [Review Am. Ch. Res. 9, 151 (1903)] says "Eastern assayers had reported the metal in the ore to be platinum and palladium." (?)
1903	*Brillium*.......	Coal ashes....	Reporter's fertile brain.	Washington Post, Nov. 18.	Special correspondence from Newark, N. J. Reported presence of material in coal ashes, which produces more heat when placed under furnace than fuel bought from trust.
1903	"Radium-foil"..	Zinc-bearing minerals.	Kunz and Baskerville.	N. Y. Acad. Sci. Oct. 6; Am. J. Sci. Jan.,	Zinc oxide and sulphide, willemite and kunzite (which contains zinc) fluor-

				1904, and Science 18 (N. S.) 769.	esce, and phosphoresce with Roentgen rays, ultra-violet light, radium and actinium preparations, even shielded.
1903	New element ?..	Minerals from Mono Lake, Calif.	Kunz and Baskerville.	N. Y. Acad. Sci. Oct. 6; Am. J. Sci. Jan., 1904, and Science 18 (N. S.) 769.	Every mineral without exception and regard to chemical composition from this lake phosphoresces with ultra-violet light. Considering the formation of these minerals they appear to have some common constituent giving this response. Whether it be new cannot be stated, but the observations are sufficiently unique to place on record for subsequent investigation. See the full paper for other somewhat similar observations with other minerals.
1903	Radiotellurium..	Pitchblende...	Marckwald...	Ber. 36, 2662...... ..	Dark colored strongly active substance from bismuth out of Joachimsthal pitchblende. Different from polonium, radium, and actinium.
1903	Tellurium X....	Tellurium	Pellini........	Gaz. Chim. ital. 33, II, 35.	Maintains presence of constant small radio-active constituent [See Marckwald (Ber. 35, 2285)] with atomic weight about 212, which causes tellurium to hold its present anomalous position in the periodic table.

PROPOSED CHEMICAL ELEMENTS—Concluded.

Date.	Name of Element.	Source.	Authority.	References.	Remarks.
1903	Berzelium	Thorium	Baskerville. . .	Presented before N. C. Section, Am. Chem. Soc. Nov. 28, A. A. A. S., Dec. 29.	Obtained by fractioning thorium chlorides during production by volatilization. "Weisser dampff" of Berzelius, hence name. Oxide does not phosphoresce with ultra-violet light, while thorium oxide does. Atomic weight (impure material) 212.7, when regarded tetravalent.

PAPERS READ.

[The following papers were read before the American Chemical Society and Section C, in joint session.]

THE TERNARY SYSTEM, BENZENE, ACETIC ACID AND WATER. BY A. F. LINCOLN.

THERMOMETRIC ANALYSIS OF SOLID PHASES. BY WILDER D. BANCROFT.

A METHOD OF GRADING SOAPS AS TO THEIR DETERGENT POWER. BY H. W. HILLYER.

THE DETERMINATION OF GLIADIN IN WHEAT FLOUR BY MEANS OF THE POLARISCOPE. BY HARRY SNYDER.

FACTORS OF AVAILABILITY OF POTASH AND PHOSPHORIC ACID IN SOILS. BY G. S. FRAPS.

THIRTY YEARS' PROGRESS IN WATER ANALYSIS. BY ELLEN H. RICHARDS.

A STUDY OF THE NITROGENOUS CONSTITUENTS OF MEATS. BY H. S. GRINDLEY.

SOME DOUBLE SALTS OF LEAD. BY JOHN WHITE.

THE THEORY OF VALENCE. BY G. B. FRANKFORTER.

THE THEORY OF DOUBLE SALTS. BY JAMES LOCKE.

WERNER'S THEORY OF VALENCE AND THE CONSTITUTION OF COMPOUNDS. BY J. E. TEEPLE.

SOLUBILITY OF GOLD IN CERTAIN OXIDIZING AGENTS. BY VICTOR LENHER.

ON A METHOD FOR PREPARING SALTS WITH A DEFINITE NUMBER OF MOLECULES OF WATER OF CRYSTALLIZATION. BY LAUNCELOT W. ANDREWS.

AN INTERESTING DEPOSIT FROM CITY WATER PIPES. BY E. H. S. BAILEY.

A METHOD OF DETERMINING THE TOTAL CARBON OF COAL, SOIL, ETC. BY S. W. PARR.

THE APPLICATION OF PHYSICAL CHEMISTRY TO THE STUDY OF URIC ACID IN URINE. BY F. H. MCCRUDEN.

INVESTIGATION OF THE BODIES CALLED FIBER AND CARBOHYDRATES IN FEEDING STUFFS, WITH A TENTATIVE DETERMINATION OF THE COMPONENTS OF EACH. BY P. SCHWEITZER.

THE DIELECTRIC CONSTANTS OF SOME INORGANIC SOLVENTS. BY HERMAN SCHLUNDT.

CONCENTRATION CELLS IN LIQUID AMMONIA. BY HAMILTON P. CADY.

THE ACTION OF AMMONIA UPON SOLUTIONS OF COPPER SULPHATE. BY JAMES LOCKE.

PHOSPHORESCENT THORIUM OXIDE. BY CHARLES BASKERVILLE.

ON THE ACTION OF RADIUM COMPOUNDS ON RARE EARTH OXIDES AND THE PREPARATION OF PERMANENTLY LUMINIFEROUS PREPARATIONS BY THE MIXING OF THE FORMER WITH POWDERED SUBSTANCES. BY CHARLES BASKERVILLE AND GEO. F. KUNZ.

ACTION OF ULTRA-VIOLET LIGHT ON RARE EARTH OXIDES. BY CHARLES BASKERVILLE.

THE RIPENING OF APPLES. BY W. D. BIGELOW, H. C. GORE AND B. J. HOWARD.

DISSOCIATION PHENOMENA OF THE ALKYLE HALOIDS AND OF THE MONATOMIC ALCOHOLS. BY JOHN URIC NEF.

SYNTHESIS OF THE QUINOLINE SERIES. BY EDWARD BARTOW.

THE LIFE OF A BARLEY CORN. BY ARVID NILSON.

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ADDRESS

BY

C. A. WALDO,

VICE-PRESIDENT AND CHAIRMAN OF SECTION D FOR 1903.

MATHEMATICS AND ENGINEERING.

A few years ago technical education as we now understand it was unknown in America. We have now in our midst more than 20,000 students preparing themselves distinctively for the engineering profession.

While the technical schools of the country have had a development which for rapidity, strength and importance partakes of the marvelous, their rise and growth have been profoundly influencing the thought as well as the welfare of the nation. Especially in the domain of mathematics have they had a directing and vivifying influence which is little short of a revolution. To-day mathematics wishes no stronger reason for her existence and no stronger call to her cultivation than the fact that she is the unchallenged doorkeeper to the appreciation and mastery of the physical sciences, both in their theory and in their application by the engineer to the constructive arts.

The time is passed when mathematics is referred to by the thinkers of the day as being principally a discipline. It is, of course, true that, rightly pursued, mathematics is a discipline, but it is far more, it is a knowledge, a tool, a power, a civilizer. The day is gone when on the one hand the student, Chinese fashion, learns his geometry word for word

from cover to cover, or memorizes all the demonstrations of his analytic geometry down to the last index and subscript, or, on the other hand, when the devotee of a cult toasts his favorite subject with the words "Here's to the higher mathematics, may they never be useful."

To the workaday world the higher ranges of mathematics have been a sealed book; the man who traverses them successfully a magician—a man whose mental occupations awaken mingled feelings of awe and pity, awe that he can soar so high, pity that he wastes his strength in such useless flight. A generation ago the mathematician was joined in hand with the Roman and the Greek, and the three easily persuaded the educational world that they were the divine trio. Without them for a basis there could be nothing but a sham college course. Why it was that these three lines of study held such a commanding and for the most part unchallenged position it is now difficult for us to say. Possibly they gained higher esteem as means of mental discipline because their most ardent votaries so seldom succeeded in making them directly useful except in certain narrow professional lines. Of the men in college courses who studied required mathematics beyond trigonometry, very few gained any vital conception of analytic geometry and the calculus. To most collegians the mass of symbols with which they juggled in pursuing these subjects was a distressing nightmare, a matter of jest and to be forgotten with all possible speed.

Our colleges to-day have seen a great light, and have reformed their curricula. They now know there is no discipline in the pursuit of mathematics to the man who does not understand its language. Early in his course, if not throughout it, the student is allowed the more rational way of getting his education—by pursuing subjects that he *can* understand. This sensible treatment of educational material has grown up during the development of technical colleges, and may be referred in a measure at least to their influence. Certainly great advance in the teaching of mathematics has recently been made, yet very much remains to be

done, and the next great forward movement seems to be coming directly from the engineers and the forces they are setting in operation.

The literature on the question of reform in the teaching of mathematics is growing rapidly. In 1901, John Perry, Professor of Mechanics and Mathematics of the Royal College of Science, London, and Chairman of the Board of Examiners of the Board of Education in Engineering and Mathematics, produced a profound impression upon the British Association by a paper on "The Teaching of Mathematics." His ideas require attention further along. In Germany, Nerst and Schoenflies, for example, have met the thought of the hour in their Einführung in die Mathematische Behandlung der Naturwissenchaften. In our own country Perry centers are springing up for the reformation and profound improvement, if not revolution, of mathematical teaching in our secondary schools. In the west the apostle of this movement is Professor E. H. Moore, of Chicago University. One needs only to read his admirable presidential address before the American Mathematical Society in New York, almost a year ago, to understand the full meaning and extent of the changes sought.

The address will be found in the number of the Bulletin of the American Mathematical Society for last May, and it will repay a careful perusal on the part of those of you who have not read it. Professor Moore has been counted as a pure mathematician of the most pronounced type, but into this new movement he has thrown himself with the ardor of one whose whole life had been spent in applying a wide range of mathematical power to the design and construction of the great objects of engineering. If the reformation which has been planned and begun shall go on to completion, the mathematical teaching in the secondary schools of the middle west will have little resemblance ten years hence to the work of to-day.

Arithmetic, algebra, geometry and trigonometry will no longer be set off in "water-tight compartments," but will all be demanded in various combinations for the solution of

single elementary problems. Squared and polar co-ordinate paper will represent the facts to the eye in geometrical symbolism, and at the same time will give a practical introduction to the fundamental ideas of analytics and the calculus. By pursuing through the four years of secondary school life a carefully selected and properly graded problem course the pupil will review the whole range of elementary mathematical truth and become familiar with it not only in theory but also in practice. He will never be asking, "What use?" But with the enthusiasm which original investigation only can arouse he will find his educational material in the simpler problems of the shop, the store, the farm, the bank, the railroad, the steamboat, the steam engine, the electric motor, political economy, geodesy, astronomy, time, space, force, and so on through the range of the elementary aspects of the things of daily thought and experience in this complex and highly developed life of ours. Such a change cannot be perfected in a day. No inferior or untrained teacher can succeed with it. Elementary work should be in the hands of those who have come into living contact with some of the deep, broad problems of chemistry, of physics and of engineering, demanding for their solution a large acquaintance with the higher ranges of mathematics. In turn colleges and universities which strive to train such teachers must revise their mathematical courses and adjust themselves to these new ideas.

In many of our leading institutions exactly that thing is occurring, stimulated perhaps in the first place by the great demand of technical colleges for mathematicians in sympathy with engineering ideas.

Those who are dealing with freshmen in colleges are asking the question: "What is the matter with our preparatory schools?" If you wish to see this question strongly formulated and illustrated read the Commencement Address of 1903 by President Ira Remsen at Mount Holyoke College.

This is the indictment of the schools, that they use, largely to the exclusion of the thought element, a mass of formal and conventional educational material, and thus paralyze thought and crowd out natural mental growth.

In the grades the clear, keen, accurate thinking of childhood soon disappears and does not usually show itself again until the laboratory or the practical problems of life make it once more dominant. We refer to President Remsen's question only so far as it relates to mathematical training. The technical schools long ago recognized the barren results of primary and secondary mathematical instruction and have been deeply interested in its improvement. Most keenly this barrenness of earlier years has come to the engineer who must subject himself to the long hard discipline necessary in his profession for the successful solution of his original and independent problems. Yet certain people seem to look askance upon the engineer and discover no advancement of science in the design of an entirely new machine to carry out an entirely novel idea. According to their notion, Whitney was not a scientist when he invented the cotton gin, nor Fulton when he constructed the first steamboat, nor Morse when he perfected the telegraph.

This was all pure commercialism. Even if these worthies cared nothing for the financial side of their work, and only sought to serve and benefit their fellow men, they could not be classified with the man who describes an unrecorded bug, or the one who makes a new but useless chemical compound. The latter work without the hope of direct money return for their labors. Therefore, theirs is the true method and the superior life, even when their disinterested consecration to science is mingled with a hope that a little fame will bring them an increase in salary from some practical person or persons who appreciate their unselfish efforts.

However all of this may be, we know that the essence of any engineering work worthy the name is its independence. With this there is usually some degree of originality, as it seldom happens that the same problem repeats itself in every particular. What is more, with the independence and originality of the engineer must come character, confidence in his own mental processes, and a willingness to shoulder responsibility in embodying his conclusions. A scientist may announce his discovery of the tidal evolution of the moon

and yet be forgiven if later it should be shown that he is in error. Not so with the engineer. When his bridge falls under prescribed conditions of safe load, his own ruin as well as that of his structure is complete. Of all men living the intellectual life the engineer is the one most interested in sound and logical training for his profession, and most intolerant of all shams. It is not surprising then that the one subject in secondary schools whose natural purpose is to train the student to severe logical and productive thinking should respond most fully to his influence. Neither is it surprising that from the ranks of the engineers should come the reformer who sees clearly the defects of our present mathematical work in the lower grades and who is moving powerfully to secure better conditions.

We may sum up what now seem to be the best ideals in secondary mathematics as follows:

These ideals come from the engineering professions.

They insist upon quality rather than quantity.

They insist that the thought shall precede the form; that the symbol shall not conceal the thing symbolized.

They insist that systematic and progressive problems based upon everyday experience and observation shall be to a much greater extent the materials of education.

They insist that the problems shall be largely concrete and shall be worked out to an accurate numerical result.

They demand that the several elementary mathematical subjects from arithmetic to the calculus shall develop side by side in the boy's mind.

They demand that the mastery of these subjects shall be more the work of the judgment than of the memory.

They demand that from first to last, at least during the secondary period, mathematical ability and the ability to think clearly, investigate closely, and conclude correctly shall develop together, and to the extent that four well spent years will on the average permit.

Those who formulate these ideals contend that they lead to the correct mathematical training for all professions and all careers.

It remains for us to consider the mathematical courses in our technical colleges. What is their relation to the development of the engineer? What shall they include? How shall they be administered? These are not new questions, neither has the last word been said in answer to them. Fifteen years spent in directing engineering mathematics gives the writer some excuse to undertake some further discussion of them.

Important contributions along this line were made by Professor Mansfield Merriam in 1894 and Professor Henry T. Eddy in 1897, whose articles are published in the Proceedings of the Society for the Promotion of Engineering Education, the second and fifth volumes. But among the most suggestive discussions during the last year, as well as all previous years, are the papers of some of our brightest electrical engineers presented at the joint meeting last July at Niagara Falls of the Society just mentioned and of the American Institute of Electrical Engineers, and published this year in the proceedings of both societies. To those interested in finding the best educational conditions leading to the average as well as the most important engineering operations of the day these papers come with peculiar weight and authority. Judging from the expressions of opinion contained in them the active engineer in his occupation, at least, cares nothing for the philosophic basis of the concept of number, nor for the geometry of non-Euclidean space, nor for Grassman's *stufe* of the 5th or 6th degree, nor for computations of plane triangles when the sum of the angles is less than 180 degrees. These subjects may and should interest the professional mathematician, but the engineer asks first for the ability to use numbers rapidly and to carry numerical computations, no matter how complex, to an accurate conclusion. As for ordinary mathematics, including of course elementary geometry, algebra and trigonometry, the engineer should know them "as he knows the currency of his native country. In other words, he ought to be able to make change with ease, quickness and accuracy—not as if one were in a foreign country in a constant state of painful reckoning."

On a basis of barter modern business would be strangled. The very existence of commerce in the modern sense, in which the line of cost and profit is so finely drawn, would be utterly impossible without a standard currency. So without mathematics engineering would be a mass of empiricism and tradition. Instead of a pioneer leading the way in the progress of the peoples it would be an outcast trailing in the rear of every science.

This proposition that mathematics is the very bone and sinew of an engineering course needs no discussion. It is everywhere conceded. The extent and nature of the mathematical element in the curriculum, however, are two decided fluents with curves of opposite slope. More mathematics but fewer kinds seems to be the tendency. The opinion appears to be gaining ground that the purely descriptive and highly specialized and professionalized elements in our technical courses should be reduced, while more subjects with a mathematical basis, with long unbroken continuity and bound together with a strong logical element should command the attention of the student to the end of his undergraduate period.

Upon the question what mathematical subjects shall the undergraduate courses include in our technical colleges, opinions are decidedly at variance. Upon the four ordinary elementary subjects the sentiment is practically unanimous, but these should be principally taught in the secondary schools. The practical people, however; are inclined to relegate analytic geometry and the calculus to the scrap pile.

To such subjects as vectors, theory of functions, theory of groups, they allow no place whatever.

One cannot but feel that this verdict against analytic geometry and the elementary calculus, not to mention higher subjects, is a great pity. Especially does it seem true when we recall that instruction in these two lines forms the principal mathematical element of the second and third years of the ordinary technical course, and that the calculus itself is probably the most powerful and wonderful tool for investigation that the genius of man has ever contrived. . . . .

The student of mathematics who has reflected deeply upon the meaning and interpretation of its symbolic language knows that man in his struggle for the mastery and direction of nature's laws and processes has no more subtle and no more powerful ally than he finds in the calculus. The other subjects leading to it are conventional and highly artificial, but with this one we return to simplicity and operate with perfect ease and freedom in the realms of time, space and force.

As we find nature operating by growth, and force by insensible gradations, so over against that the calculus is the science of continuous number. Why then does the mathematician find so much in this, his favorite subject, while the practical engineer, even the one of great ability, proficiency and success, is inclined to think that time spent upon it is wasted or at least not employed to the best advantage? Why this great divergency in conviction?

No one will doubt the ability of our best mathematical instructors nor their perfect familiarity with the matter they are teaching. But are analytics and the calculus—especially the latter—presented to the average student in the best way? Does not the former smother the thought element and leave nothing but routine machine work upon symbols? As the student learns laboriously how to find the first derivative of a wide range of *rider* problems has he a faint conception even of what it is all about? Sir William Thompson, you know, said he did not understand an equation until he could make a model of it. Is the average student able to make a model of his operations with the differential calculus? And when he takes up the integral calculus and begins his attack upon a mass of algebraic and transcendental functions, using at times devices of great complexity and extreme refinement, does he usually walk by sight or by faith? Does he not often go forward on long and painful journeys in utter darkness as to the meaning of it all, trusting, hoping, praying that by and by his teacher and his text-book will land him on solid ground, and in the clear light to revel and operate in a new world of thought and action? How many men of

good natural endowments, who are sorely needed in the higher ranks of the world's workers, become terrified in this period of distressing gloom; how many have lost individual initiative and independeuce and are content thenceforward to walk not upright, vigorous, aggressive, daring, in the clear light of right reason, but by faith, humble and submissive!

Why do practical men almost unanimously place calculus among the dispensable elements of a technical curriculum?

The answer, of course, is very simple: they have never found any use for it, probably because they have never learned how to use it. Yet they dare not pronounce against it altogether. They know that Rankine and Maxwell were master mathematicians, and that through this mastery of the most powerful of tools they were able to do for terrestrial, what Newton and Laplace did for celestial mechanics. In college, the engineer has not learned to use the modern tool called the higher analysis; it remains to him as foreign currency. Out of college he has not time to learn its use. Are you a teacher of mathematics and did you pursue the subject under the direction of a master? Yet how many classes did you yourself guide through the calculus before its hidden meaning, its range, its versatility, its power were in any adequate measure revealed to you? How simple and how majestic it has now become! But if you were so slow in reaching the true light, is it to be wondered at that students who go over the subject but once and under conditions not greatly superior to those of your own college days should not see clearly and should not use what they so little understand! Because, as matters now stand, the man who does not repeat his course in calculus many times will fail to appreciate it and use it, shall we say that it should be cut out of the engineering courses and its place taken by more algebra, more trigonometry and more descriptive geometry, or shall we retain it and reform its presentation? The true mathematical teacher will always vote for the latter proposition, whatever may be the attitude of the professional man on the faculty or the pressure from the outside of the practicing engineer.

How then may the higher analysis in our technical schools be made effective as a true means of discipline and as a tool with which to equip the engineer in his life of investigation?

It is to be understood that the answer to this question here is not claimed to be *the word* nor the *last word* on so important a topic. It is *a word* to be taken for what it is worth.

1. The most effective teaching of the higher analysis will be possible only when the reforms in mathematical instruction referred to earlier in this paper have permeated the principal secondary schools.

2. The teacher should be saturated with his subject. Not only should he be strong and apt on the formal side, but more important still its inner meaning should be clear to him and its close relation to the phenomena of the objective and subjective life. Some contend that the only man to whom the mathematics of a technical college can be entrusted is an engineer. Does that make any difference? Rather are not these the essential questions: Does the man know his subject? In his teaching can he assemble from engineering and other records the material that will vitalize his work? Is he in sympathy with engineering essentials and ideals?

3. Throughout the college course the teaching should be mainly concrete. The problem, say from the physical sciences including engineering, should first be presented to the mind. It should then be stated in mathematical symbols. The operations performed upon the symbols should be accompanied by drawings or models, the final result reduced to numerical form and then interpreted in language. Upon every problem the student must bring to bear the whole range of his acquired powers and be taught to select the shortest method within his ability.

In other words, all typical problems should receive a three-fold consideration: (*a*) its statement in words, and the statement in words of its solution when effected; (*b*) its graphical statement and solution involving geometry and mechanical drawing with squared paper; (*c*), its analytic statement and solution, ending with a numerical result.

4. The purely formal should be presented as a necessity

arising from the so-called practical, and in order that a body of knowledge and technical ability may be accumulated which will give the student easy control over the practical in whatever one of its various forms experience shows that it may arise.

5. The problems chosen should be progressive in character, and their mastery should amount to a complete laboratory course in all that part of the higher analysis in which it is desirable that the engineering student should be well versed.

6. The course should be lecture and seminarium and individual, more after the manner of the German Technische Hochschule. The text-book should become a book of reference. The instructor should know clearly and be able to state accurately the limitations of his methods; but abstruse discussions of obscure points should be postponed as long as a due regard for logical development will allow. Time is wasted in removing difficulties whose existence and importance the student has not yet recognized.

These are some of the necessary extensions into college work of the reformation now urged upon the secondary schools, and though every one of them seems familiar enough when taken separately, all together their united application to the mathematical courses in our technical schools amounts to a departure from our present traditional methods little short of revolutionary. Yet isn't this the thing our engineers are demanding, and isn't this the logical way to train an engineer in higher mathematics? Isn't it the way to approach the higher mathematics anywhere or in any kind of a school?

The pure mathematician may object and exclaim, what is to become of our curricula which have been evolved after so many years of intellectual conflict! The rule is so much algebra, so much geometry, so much trigonometry, so much analytical geometry and so much calculus. At the end the student has passed with greater or less success so many formal examinations upon so many formal topics, and his acquirements are supposed to range somewhere between the maximum and minimum grade of passing. But are these the questions which the enlightened educator of to-day is

asking? Is it not, *How much power?* A dry and fruitless familiarity with a number of highly specialized and unrelated things cannot be education. The engineers demand that the unity of the mathematical branches should be emphasized and that they should accumulate in the soul of the student not as dry, useless and unrelated facts, but as a magazine of energy.

Little has been said in this paper about descriptive geometry and mechanical drawing as necessary parts of a general mathematical training. Both of these subjects are of the highest value as disciplinary studies. They make definite and effective other mathematical material. Is not one reason for the barrenness of mathematics in university courses the fact that these subjects, simple though they are, have been so long neglected? Do we not find one important explanation of the effectiveness of mathematical training in technical schools the fact that these subjects are always a part of their curricula?

You may ask for some definite concrete expression upon the way that the study of calculus should be undertaken. This paper will close with an attempt at a brief answer to this question.

We will suppose that experimentally or otherwise the student is familiar with the equation of falling bodies, $s = \frac{1}{2} gt^2$. By this time also the student must be somewhat skilled in the use of squared paper and acquainted with this curve itself through its application to parabolic mirrors or otherwise. Perhaps our parabola had been studied from its geometrical side as a conic section. It now takes on a symbolic meaning, for it gives in a certain sense a picture of the first law of falling bodies. But does the student grasp the full meaning of the picture? Using the approximation $g = 32$, we have a numerical equation. The abscissas of the curve represent elapsed time, the corresponding ordinates represent total space traversed. At some point on the curve proceed geometrically and analytically to construct the tangent, at every step making a threefold interpretation, one of the curve, one of the analysis, and one of the fact connected with these in the

familiar phenomena of a falling body. Show the limiting position of the secant, deduce the number towards which your successive numerical approximations tend, and connect both of these with the velocity of the body at the point considered. Draw the tangent and show how it represents uniform velocity. Show that the results reached at one point on the curve are general and apply equally well to every point, and that everywhere on your curve your geometrical tangent and your analytic limit interpret each other and give the rate or velocity of the falling body.

Note that the tangents are changing, that the corresponding numbers are changing, and that these constitute a rate of change of velocities. Show graphically the oblique straight line representing the changing velocities. Give its graphical, its numerical and its nature interpretation. In the same way study the line parallel to the axis of abscissas representing gravity. Study the graphs and their relation to each other. Study the series of numbers resulting from the selection of equal increments along the X-axis, the relation, therefore, of these operations to the theory of number series. Connect the first differential coefficient with the tangents and with rates, the second with the changes of tangents or of rates of tangents, and thus with the thing in this problem that produces the changes of velocities, that is, with the force of gravity. Note the deformation of the original curve if the resistance of the air had been considered and its influence accounted for by some simple law. Construct the curve of the body projected upwards. Let up and down destroy each other, so that the ordinates at each point will be the algebraic sum of opposite motions. Note the point in the curve when the projected body is for an instant stationary in the air. Observe its connection with the first differential coefficient. Note the deformation of the curve due to the resistance of the air acting according to some assumed law.

Similarly, construct approximately the smooth integral curve which represents the movement of a steam railroad train from station to station fifty miles apart. Con-

nect the contour of the curve with velocities and with forces, including in the latter the steam in the cylinder, gravity, assisting or retarding, friction and air resistance always retarding. Note how the second differential coefficient carries us back to steam in the cylinders, the third to the causes leading to a variation of the artificial forces, such as fuel, skill in stoking, &c. Pursue maxima and minima problems in the same way. But now instead of a rate of change directly dependent upon a conventional unit of time we have relative rates of change, and we quickly enlarge our ideas of the meaning and application of the first and second differential coefficient. We can safely begin the formal element of the subject. Even then we should continue the diagram and its interpretation though we may be utterly unable to set the highly artificial equation over against any definite problem known to exist in nature.

Just as differentiation always has a symbolic interpretation in tangents and rates, so the integration of any expression may be interpreted as the finding of an area.

Reverse the series of curves relating to falling bodies. The straight line parallel to the axis of x represents the action of gravity, assumed to be constant. The oblique straight line through the origin sums its areas and shows that the rate of growth of the velocities is constant. In turn the vertical parabola picturing time and space is the integral curve of the velocities.

From engineering we have a remarkable series of connected quantities and these may be selected, as given by Prof. W. K. Hatt in the Railroad Gazette of December 23, 1898, for illustrating the cumulative effect of successive integrations. Five successive diagrams used in engineering practice are connected by integrations. These are in their order the load diagram, the shear diagram, the moment diagram, the slope diagram, and the deflective diagram.

But it is not necessary to enter further upon specific illustration. The higher analysis is replete with problems which the skilled teacher may use as stepping-stones by which he may help the student to pass with safety to higher and

higher mathematical attainment. Step by step he masters his method while he is gaining a clearer insight into the causal relations of things about him.

The thought element is ever dominant. He goes from strength to strength until no task seems too difficult for his disciplined powers.

Two young men stand before an intricate machine. They are told that their success in life depends in large measure in their ability to understand and use it. One examines piece by piece the parts of which it is composed. He discovers the way in which these parts are connected, the material of which they are made, their size, their strength, their beauty. After long and arduous study, he knows very much about the machine, but he cannot put it in motion, he cannot make it work, he can do nothing with it except to admire its perfection of form.

The other student begins to construct another machine like the one shown him. As it grows under his hands he is constantly using it for every operation to which it can be applied. As it approaches completion he admires more and more its adaptability and wide range of useful applications. Its beauty no longer affects him greatly, but he is lost in wonder and admiration before its marvelous power. By directing and using this power he grows in wisdom, in mentality and in originality, and becomes one of the benefactors of his race.

Do we need to stop long to discover who is the "man thinking"?

In later years mathematical instruction in this country has greatly improved in its thought content, but it has responded slowly and conservatively to modern methods. We are still more English than German. In the work of training a master of the physical sciences the text-book and the senseless repetition of words and formulas falling upon the dull ear of an instructor half asleep have been replaced by the lecture, the laboratory, and the seminarium. Why should not mathematics, so intimately related to them, follow their lead and partake in the benefits of modern methods carried to their legitimate and logical completion?

PAPERS READ.

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New Features and Tendencies in Bridge Engineering. By H. S. Jacoby.

An Hydraulic Micrometer Caliper. By Wm. T. Magruder.

Pitot Tubes, with Experimental Determinations of the Forms of Water Jets. By James E. Boyd and Horace Judd.

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THE SCIENCE OF SMOKE PREVENTION. BY C. H. BENJAMIN.

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SOME TOPICS CONNECTED WITH THE MACHINERY DEPARTMENT OF THE WORLD'S FAIR. BY G. L. CARDEN.

METHODS OF DETERMINING THE COEFFICIENTS OF ELASTICITY. BY FRANK B. WILLIAMS.

A PROPOSED METHOD OF BUILDING THE MANDINGO SHIP TUNNEL. BY E. W. SERRELL.

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ADDRESS

BY

W. M. DAVIS,

VICE-PRESIDENT AND CHAIRMAN OF SECTION E FOR 1903.

GEOGRAPHY IN THE UNITED STATES.

For twenty years past our section has acknowledged in its name an equal rank for Geology and Geography, but not one of the vice-presidential addresses during that period, or indeed since the foundation of the Association over fifty years ago, has been concerned with the subject second named. Unless we cross off geography from the list of our responsibilities, it should certainly receive at least occasional attention; let me therefore depart from all precedents, and, even though geologists may form the majority in this gathering, consider the standing of geography among the sciences of the United States: how it has reached the place it now occupies, and what the prospects are for its further advance.

One measure of the place that geography occupies in this country may be made by considering the share that geographical problems have had in the proceedings of our Association: here follow, therefore, the results of a brief examination of our fifty volumes of records. In the early years of the Association there was no fixed division into sections. The meetings were sometimes so small that papers from various sciences were presented in general session. At least once in the early years the work of our predecessors was recorded under the general heading, "Natural History, etc." As early as in 1851 there was a section of geology and physical geography, and another of ethnology and geography,

but that classification did not endure. Once only, in 1853, did geography stand by itself as a sectional heading, but at many meetings physics of the globe and meteorology had places to themselves. Through the '60's and '70's geography was sometimes coupled with geology, but the latter more often stood alone or with paleontology, and it was not until the Montreal meeting of 1882 that Section E was definitely organized with the title that it now bears.

In those years when physics of the globe and meteorology were given sectional rank, problems concerning the ocean and the atmosphere received a good share of attention. It is curious to note, in contrast to this, how little consideration has been given to the exploration and description of the lands; that is, to the geography of the lands, in this Association for the Advancement of Science, either before or after the establishment of the double name for our section. The exploration of foreign lands, for many years a prominent subject in the meetings of the British Association where geography has had a section to itself since 1869, has attracted hardly any notice in our gatherings; perhaps because we have been busy exploring our own domain. At the first meeting, 1848, a summary of then recent explorations, prepared by Alexander, is the only paper of its kind. Other papers treating the geography of foreign lands are so few in number that most of them may be noted here; in 1850, Squier gave an evening address on the Volcanoes of Central America; in 1858 and 1860, Hayes and Wheildon discussed Arctic Exploration; Orton described the Valley of the Amazon in 1869; in 1884 and 1898, two English visitors had papers on different parts of Asia; in 1891 and 1898, Crawford described features of Nicaragua, and in 1894 and 1895, Hubbard read papers on China, Corea, and Japan. Even geological essays on foreign regions have been few; Dana, Branner, Hill, Spencer, Heilprin and Hitchcock being the chief contributors. Inattention to foreign exploration is, however, not to be fully explained by devotion to the geography of our own country, so far as the latter is measured by the pages devoted to it in our proceedings. The first meeting started

well enough, with accounts of the terraces of Lake Superior by Agassiz, of the physical geography of northern Mississippi by Bolton, and of the topography of Pennsylvania and Ohio by Roberts. Again, in 1851, when physical geography was named with geology, the first subject had two essays, the distribution of animals in California, and the climate, flora, and fauna of northern Ohio; and geography joined in the same year with ethnology had three rather scattering titles: a deep-sea bank near the Gulf Stream, measurement of heights by the barometer, and a geographical department in the Library of Congress; but this beginning had no worthy sequel. The many expeditions across our western territory contributed little geographic matter to our records; in 1856, Blake described the orography of the western United States, and Emory the boundary of the United States and Mexico; and the latter added in 1857 an account of the western mountain systems of North America. From that time onward there has been very little primarily of a geographical nature concerning the United States. Even the modern discussions of glacial geology in the last twenty years, profitable as they have been to the physical geographers of glaciated regions, have in very few if any cases been presented as contributions to geography. The new phase of the physiography of the lands is scantily represented; there have been hardly more than accounts of Mexico by Hill, of California by Perrin Smith, of North Carolina by Cobb; it is to be noted, moreover, that these three authors are primarily geologists, not geographers. This meagre showing leads one to suspect that our proceedings do not give a fair measure of geographical activity in North America.

There has been in reality a great deal of work of a geographical nature done by our people, but the proceedings of the Association do not seem to have commended themselves as a place to put the work on record. Our geological surveys, state and national, have contributed numerous geographic chapters and reports of prime value; our Weather Bureau is in many respects the leading institution of its kind; our Coast Survey sets a high standard for triangulation, coast

maps, and tide and current studies; we have held a prominent place in Arctic exploration, and have taken some part in exploration elsewhere. But in spite of all this accomplishment, we have not made great contributions to the full-fledged science of geography. There are, for example, few steps toward scientific geography of greater value than good maps, but for the geographer to stop with the production of good maps is as if the botanist stopped with the collection of dried plants. The survey reports of our various States and Territories contain a great fund of geographical matter, and some of the members of these surveys have carried the physical geography of the lands so far forward as to develop it into a new science, to which a name, geomorphy or geomorphogeny, has been given; yet geography has not flourished among us as a maturely developed subject. The survey reports have not, as a rule, been prepared by persons whose training and interests were primarily geographical, and very few of the geomorphogenists have carried their new science forward into a geographical relation; they have usually stopped with the physical aspects of the subject, and left the organic aspects with scanty consideration. It is as if there had been some impediments in the way of the full development of geography as a maturely organized science. There are in fact three serious impediments.

During all these years geography has suffered greatly from being traditionally a school subject in its educational relations; the subject as a whole has been almost everywhere omitted from the later years of college and university training, although certain of its component parts have received some attention in college years. Again, geography as a whole leads to no professional career outside of school-teaching; it is perhaps chiefly on that account that our colleges and universities can give little time to it. Finally, there is not to-day in this country an organized body of mature geographical experts at all comparable in rank to the bodies of physicists or of zoologists which are organized into effective working societies; in the absence of such an organization geography suffers greatly for the lack of that aid which

comes from mutual encouragement among its workers. How can we remove these impediments of low educational rank, no professional career, and no professional organization?

Geography will find a place in our colleges and universities very soon after it is shown to be a subject as worthy of such a place as are the subjects whose position is already assured. Physical geography is to-day slowly winning a more respected place than it has ever had among the subjects on which examinations are set for admission to college. Commercial or economic geography is, I believe, destined to attract increasing attention from mature teachers and nearly mature students. The general geography of various parts of the world must receive more and more consideration in our colleges during the century that opens with the outgrowth of our home country; and just so soon as mature teachers of mature geography can make their lectures of value to the young men of to-day, who are to be the leaders of enterprise to-morrow, place will be found for geographical courses in our higher institutions of learning. Progress in this respect is visible, though not rapid. In order to hasten progress, increased attention might well be given to so-called practical courses in geography, as well as to courses of a generally descriptive nature. The impediment of low educational rank is not permanent; it need not discourage us, for it is destined to disappear.

The study of geography is not likely soon to lead to a large, independent career, but it may be made useful in many careers, as has just been indicated. It will, however, be made particularly serviceable to a class of men that is now of small but of increasing numbers, namely, those who travel about the world, seeking fortune, entertainment or novelty. With the present rapid increase of wealth among us, this class is destined to grow, and while it may never be large, it may soon be important, and its members need careful cultivation; and at the same time the teachers of this class and of other classes with whom geography becomes important, will win a respected career for themselves. The impediment arising from the lack of a large professional career will there-

fore have no great importance when the many relations of mature geography to other subjects are recognized.

The third impediment to the maturing of geography is the most easily overcome even if at present the most serious, for its removal depends only on the action of geographers themselves, and not on the action of higher bodies, such as executive officers, trustees, and so on, or on the action of lower bodies, such as students. The absence of a society of mature geographical experts is the fault of the experts themselves. No greater assistance to the development of mature scientific geography lies within our reach than the establishment of a geographical society which shall take rank with the Geological Society of America, for example, as a society of experts, in which membership shall be open only to those whose interests are primarily geographical and whose capacity has been proved by published original work in a distinctly geographical field. In order to determine whether such a society can now be organized, I propose to consider the classes of persons in the community from which the members of the society could be recruited.

There are at least four classes of geographical associates, as they may be called, from which mature geographical experts might be drawn. First and in largest number is the class consisting of the teachers of geography in our schools. It is true that our school teachers, as a rule, devote themselves to immature geography; that is, to only so much of the whole content of the subject as can be understood by minors, indeed by children. But, on the other hand, one who is acquainted with recent educational progress cannot fail to recognize the notable advance made in the last ten years alone in the preparation for and in the performance of geographical teaching. There are in the secondary schools to-day a number of teachers who are competent to make original, mature geographical exploration of their home country, and some of them have actually travelled east and west with the object of making geographical studies. There are several Teachers' Geography Clubs, and the leading members of these clubs are thoughtful workers. I am sure that a significant number

of acceptable members of an expert geographical society would be found in this class.

The second class of geographical associates includes the observers of the national and state weather services, who have chiefly to do with that important branch of geography comprehended under climatology; these observers are gathering a great crop of facts, not always very accurately determined or very widely applied as far as the observers in the state services are concerned; yet from among the thousands of persons thus employed there will now and then come forth the original worker whose contribution will fully entitle him to expert rank; when his published studies are seen to be of a thoroughly geographical character and of a mature grade, they would warrant his admission to a society of geographical experts.

Third comes the class made up from the members of various governmental bureaus, state and national, whose work is of a more or less geographical character; for example, topographers and hydrographers; geologists and biologists; ethnologists and statisticians: this class being as a whole of much higher scientific standing than the two classes already mentioned. It may happen that many persons thus classified have a first interest in the strictly geographical side of their studies, although faithful work in the organization to which they belong associates them with other sciences. I should expect the greatest part of the membership in a society of geographical experts to be drawn from this class.

It may be noted that the absence of a body of mature geographers, as well organized and as scientifically productive as are the workers in various other sciences, is explained by some as an inherent characteristic of geography, necessitated by the great diversity of its methods and its interests. The diversity is already an embarrassment, it is claimed, even in school years; and it afterwards compels the separation of the branches of this highly composite subject, at best but loosely coherent, into a number of specialties, each of which is so much more closely allied to other sciences than to the other branches of geography that those workers whose union would constitute

a body of mature geographical experts are found scattered among other unions, geological, botanical, zoological, ethnological, economical and historical. The claim that the disunion of geographical experts is necessary does not seem to me well founded. May we not, indeed prove that there is no such disunion by pointing to the fourth class of geographical associates, concerning whom my silence thus far may perhaps have awakened your curiosity, namely, the members of our various geographical societies?

There are at the present time between five and seven thousand such persons in the United States, but in the absence of any standard of geographical knowledge from the requirements for membership, these societies cannot, I regret to say, be taken as evidence that there is a common bond by which experts in all branches of geography are held together. None of our geographical societies are composed solely of experts, and none of them are held together by purely geographical bonds. While we must not overlook the excellent work that our geographical societies have done, neither must we overlook the fact that in making no sufficient attempt to require geographical expertness as a condition for membership, there is a very important work that the societies have left undone. They have truly enough cultivated a general interest in subjects of a more or less geographical nature, but they have failed to develop geography as a mature science. Indeed it may be cogently maintained that the absence of any standard of geographical knowledge as a condition for society membership has worked as seriously against the development of mature scientific geography as has the general abandonment of geographical teaching to the secondary schools. Large membership seems to be essential to the maintenance of good libraries in handsome society buildings, and it is certainly helpful in the collection of funds with which journals may be published and with which exploring expeditions may be equipped and sent out. I should regret to see the membership in a single existing geographical society decreased, but I regret also that there is no geographical society of the same rank as the American Mathematical Society, the Ameri-

can Physical Society, or many others in which number of members is secondary to expert quality of members. Large numbers of untrained persons are not found necessary to the maintenance of vigorous societies in which these other sciences are productively cultivated, and it is therefore reasonable to believe that large numbers would not be essential to the formation of a geographical society of high standing. Indeed, it can hardly be doubted that the acceptance of a low standard for membership in our geographical societies has had much to do with the prevailing indifference regarding the development of a high standard for the qualification of geographical experts.

Not only may any respectable person obtain membership in any of our geographical societies, however ignorant he may be of geography, but various kinds of societies are ranked as geographical, even though their object may be geographical in a very small degree. This is indicated by a list of geographical societies recently published, in which is included a small Travellers Club lately organized in one corner of our country. The object of this club is simply "the encouragement of intelligent travel and exploration." Interest in rather than accomplishment of exploration and travel suffice to recommend a candidate, otherwise qualified, for membership. The object of travel is nowhere stated to be geographical. As a matter of fact, travel for the sake of art, archæology, language, history, astronomy, geology and botany, for discovery, or even only for sport and adventure, as well as for strictly geographical objects, is encouraged by this young organization, which is really nothing more than its name claims it to be: a travellers club. The same list of geographical societies includes several clubs of excursionists, outing-takers, or mountain climbers, among whom, as a matter of fact, geography attracts hardly more interest than botany. These societies are doing an excellent work in taking their members outdoors, sometimes on walks near home, sometimes farther away to a hotel in the country, sometimes to a camp among the mountains. The chief result of such outings is an increased enjoyment and appreciation of the landscape, of natural scenery, and of everything that enters into

it; but this excellent result is by no means exclusively, perhaps not even largely, geographic in its quality.

One might question whether geographic rank was really accorded to these clubs by general assent, if their recognition in the group of geographical societies were expressed only by an individual opinion in the list referred to; but this is not the case. In preparation for the meeting of the International Geographical Congress, to be held in this country next summer, delegates to the committee of management have been invited from the Appalachian Mountain Club, in one corner of the country, and from the Mazamas in another. The delegates appointed by these clubs are, as might have been expected, men competent to act with others in organizing the Congress for us, but the same result would have been attained if delegates had been asked from the various geological, botanical, zoological, and historical societies, for all these societies contain among their members persons of a certain amount of geographical knowledge and of a sufficient executive ability. The same would be true had delegates been invited from the Boone and Crocket Club, a choice organization of sportsmen, for all such clubs have men of undoubted ability in the way of organization among their members, and are largely concerned with matters of geographical location and distribution in their activities. Nevertheless neither the sporting nor the outing clubs are essentially or characteristically geographical in their objects. Do not, however, understand me to object to the acceptance of delegates from the above-named clubs as members of the committee on management of the International Geographical Congress. I approve of the plan heartily; for in the absence of geographical societies in many parts of our country there was no other plan so appropriate. The matter is mentioned here only to show the straits to which geographers are reduced in attempting to give a national welcome to an international geographical congress; the difficulty, so far as it is a difficulty, arises from the absence among us of a body of mature geographical experts, united in an advanced acquaintance with some large part of a well-defined science. This condition of things seems to me un-

satisfactory. The absence of a strong society of geographical experts indicates an insufficient attention to scientific geography, and I therefore now turn to consider the direction in which serious efforts may be most profitably made toward a better condition of things. Let it be understood, however, that no quick-acting remedy is possible, for the reason that many of those concerned with the problem—namely, the advance of scientific geography—do not seem to recognize that the existing state of things needs a remedy. It is therefore only as a change of heart—a scientific change of the geographic heart—makes itself felt that much can be accomplished toward the development of scientific geography, and such a change is notoriously of slow accomplishment. Progress is apparent, however, and from progress we may gather encouragement. In what direction, then, shall our further efforts be turned?

Let me urge in the first place that close scrutiny should be given to things that are popularly called geographical, with the object of determining the essential content of geographical science and of excluding from our responsibility everything that is not essentially geographic. Only in this way can we clear the ground for the cultivation of really geographical problems in geographical education and in geographical societies. This scrutiny should be exercised all along the line: in the preparation of text-books, in the training of teachers, in the study of experts, and in the conduct of any geographical society that attempts to take a really scientific position. The essential content of geographical science is so large that the successful cultivation of the whole of it demands all the energies of many experts. Those who are earnestly engaged in cultivating geography proper should treat non-geographic problems in the same way that a careful farmer would treat blades of grass in his cornfield: he would treat them as weeds and cut them out, for however useful grass is in its own place its growth in the cornfield will weaken the growth of the corn. So in the field of geographical study, there is no room for both geography and history; geography and geology; geography and astronomy. Geography will never gain the disciplinary

quality that is so profitable in other subjects until it is as jealously guarded from the intrusion of irrelevant items as is physics or geometry or Latin. Indeed the analogy of the blades of grass in the cornfield is hardly strong enough. It is well known that Ritter, the originator of the causal notion in geography, and therefore the greatest benefactor of geography in the nineteenth century, was so hospitable in his treatment of history that his pupils grew up in large number to be historians and his own subject was in a way lost sight of by many of his students who became professors of geography, so-called, in the German universities, until Peschel revolted and turned attention again to the essential features of geography proper.

Close scrutiny of what is commonly called geography will certainly be beneficial in bringing forward the essence of the subject and in relegating irrelevant topics to the background; but it is not to be expected that any precise agreement will soon be reached as to what constitutes geography, strictly interpreted. Opinions on the subject, gathered from different parts of the country, even if gathered from persons entitled to speak with what is called "authority," would probably differ as widely as did the nomenclatures of the leading physiographic divisions of North America as proposed in a symposium a few years ago; but if careful consideration and free discussion are given to the subject, unity of opinion will in due time be approached as closely as is desirable.

As a contribution toward this collection of opinions, let me state my own view: the essential in geography is a relation between the elements of terrestrial environment and the items of organic response; this being only a modernized extension of Ritter's view. Everything that involves such a relationship is to that extent geographic. Anything in which such a relationship is wanting is to that extent not geographic. The location of a manufacturing village at a point where a stream affords water-power is an example of the kind of relation that is meant, and if this example is accepted, then the reasonable principle of continuity will guide us to include under geography every other example in which the way that organic forms have of doing things is

conditioned by their inorganic environment. The organic part of geography must not be limited to man, because the time is now past when man is studied altogether apart from the other forms of life on the earth. The colonies of ants on our western deserts, with their burrows, their hills, their roads and their threshing floors, exhibit responses to elements of environment found in soil and climate as clearly as a manufacturing village exhibits a response to water power. The different coloration of the dorsal and ventral parts of fish is a response to the external illumination of our non-luminous earth. The word *arrive* is a persistent memorial of the importance long ago attached to a successful crossing of the shore line that separates sea and land. It is not significant whether the relation and the elements that enter into it are of easy or difficult understanding, nor whether they are what we call important or unimportant, familiar or unfamiliar. The essential quality of geography is that it involves relations of things organic and inorganic; and the entire content of geography would include all such relations. A large library would be required to hold a full statement of so broad a subject, but elementary text-books of geography may be made by selecting from the whole content such relations as are elementary, and serviceable handbooks may be made by selecting such relations as seem important from their frequency or their significance. The essential throughout would, however, still be a relation of earth and life, practically as Ritter phrased it when he took the important step of introducing the causal notion as a geographical principle.

Thus defined, geography has two chief divisions. Everything about the earth or any inorganic part of it, considered as an element of the environment by which the organic inhabitants are conditioned, belongs under physical geography or physiography.* Every item in which the organic inhabitants of the earth—plant, animal, or man—show a response to the elements of environment, belongs under organic geography. Geography proper involves a consider-

* It should be noted that the British definition of physiography gives it a much wider meaning than is here indicated.

ation of relations in which the things that belong under its two divisions are involved.

The validity of these propositions may be illustrated by a concrete case. The location and growth of Memphis, Helena, and Vicksburg are manifestly dependent on the places where the Mississippi river swings against the bluffs of the uplands on the east and west of its flood plain. The mere existence and location of the cities, stated independent of their controlling environment are empirical items of the organic part of geography, and these items fail to become truly geographic as long as they are stated without reference to their cause. The mere course of the Mississippi, independent of the organic consequences which it controls, is an empirical element of the inorganic part of geography, but it fails to become truly geographic as long as it is treated alone. The two kinds of facts must be combined in order to gain the real geographic flavor. Geography is therefore not simply a description of places; it is not simply an account of the earth *and* of its inhabitants, each described independent of the other; it involves a relation of some element of physical geography to some item of organic geography, and nothing from which this relation is absent possesses the essential quality of geographical discipline. The location of a cape or of a city is an elementary fact which may be built up with other facts into a relation of full geographic meaning; but taken alone it has about the same rank in geography that spelling has in language. A map has about the same place in geography that a dictionary has in literature. The mean annual temperature of a given station, and the occurrence of a certain plant in a certain locality, are facts of kinds that must enter extensively into the relationships with which geography deals; but these facts, standing alone, are wanting in the essential quality of mature geographical science. Not only so; many facts of these kinds may, when treated in other relations, enter into other sciences; for it is not so much the thing that is studied as the relation in which it is studied that determines the science to which it belongs. I therefore emphasize again the broad general principle that mature scientific geography is essenti-

ally concerned with the relations among its inorganic and organic elements; among the elements of physical and of organic geography; or, as might be said more briefly, among the elements of physiography and of ——. Let me confess to the most indulgent part of this audience that I have invented a one-word name for the organic part of geography, and have found it useful in thinking and writing and teaching; but inasmuch as the ten, or at the outside twelve new words that I have introduced as technical terms into the growing subject of physiography have given me with some geological critics the reputation of being reckless in regard to terminology, it will be the part of prudence not to mention the new name for organic geography here, where my audience probably consists for the most part of geologists.

There can be no just complaint of narrowness in a science that has charge of all the relations among the elements of terrestrial environment and the items of organic response. Indeed the criticism usually made upon the subject thus defined is, as has already been pointed out, that it is too broad, too vaguely limited, and too much concerned with all sorts of things to have sufficient unity and coherence for a real science. Some persons indeed object that geography has no right to existence as a separate science; that it is chiefly a compound of parts of other sciences; but if it be defined as concerned with the relationships that have been just specified, these objections have little force. It is true indeed that the things with which geography must deal are dealt with in other sciences as well, but this is also the case with astronomy, physics, chemistry, geology, botany, zoology, history, economics. . . . There is no subject of study whose facts are independent of all other subjects; not only are the same things studied under different sciences, but every science employs some of the methods and results of other sciences. The individuality of a science depends not on its having to do with things that are cared for by no other science, or on its employing methods that are used in no other science, but on its studying these things and employing these methods in order to gain its own well defined object. Chemistry, for example, is concerned with

the study of material substances in relation to their constitution, but it constantly and most properly employs physical and mathematical methods in reaching its ends. Botanists and zoologists are much interested in the chemical composition and physical action of plants and animals, because the facts of composition and action enter so largely into the understanding of plants and animals considered as living beings. Overlappings of the kind thus indicated are common enough, and geography as well as other sciences exhibits them in abundance. It may be that geography has a greater amount of overlapping than any other science; but no valid objection to its content can be made on that ground; the maximum of overlapping must occur in one science or another—there can be no discredit to the science on that account. Geography has to do with rocks whose origin is studied in geology; with the currents of the atmosphere, whose processes exemplify general laws that are studied in physics; with plants and animals, whose forms and manner of growth are the first care of the botanist and the zoologist; and with man, whose actions recorded in order of time occupy the historian; but the particular point of view from which the geographer studies all these things makes them as much his own property as they are the property of any one else.

In view of what has been said let me return to the close scrutiny that I have urged as to what should be admitted within the walls of a geographical society. We will suppose the geography of Pennsylvania is under discussion; as a result there must be some mention of the occurrence of coal, because coal, now an element of inorganic environment, exerts a control over the distribution and the industries of the population of Pennsylvania. But the coal of Pennsylvania might be treated with equal appropriateness by a geologist, if its origin, its deformation and its erosion were considered as local elements in the history of the earth; by a chemist, if its composition were the first object of attention; by a botanist, if the ancient plants that produced the now inorganic coal-beds were studied. Furthermore, it would be eminently proper for the geologist to make some mention of

the present uses to which coal is put; or for the chemist and the botanist to tell something of the geological date when coal was formed, if by so doing the attention of the hearer could be better gained and held, and if the problem at issue could thereby be made clearer and more serviceable. So the geographer is warranted in touching upon the composition, the origin, the exploitation of the Pennsylvania coal-beds, if by so doing he makes a more forcible presentation of his own problem; but if he weakens the presentation of his own problem by the introduction of these unessential facts, still more if he presents these unessential facts as his prime interest, he goes too far. The point of all this is that students in many different sciences may have to consider in common certain aspects of the problems presented by the coal of Pennsylvania; but that each student should consider Pennsylvania coal in the way that best serves his own subject. The scrutiny that I have urged would therefore be directed chiefly to excluding from consideration under geography the non-geographic relations of the many things that various sciences have to study in common, and to bringing forward in geography all the problems that are involved in the relations of the earth and its inhabitants. The things involved in the relations of earth and life are the common property of many sciences, but the relations belong essentially to geography. It would be easy to point out topics in text-books and treatises, in the pages of geographical journals, and in lectures before geographical societies, that would not fall under any division of geography as here defined. In many such cases, however, the topics might without difficulty have given a sufficiently geographical turn, had it been so desired or intended; the topics might have been presented from the geographical point of view, so as to emphasize the essential quality of geographical study, had there been a conscious wish to this end. But in other cases, the subjects presented belong so clearly elsewhere, or are treated so completely from some other than a geographical point of view, as to fall quite outside of geography; for example, a recent number of one of our geographical journals contained an excellent full page plate and a half page of text

on the "Skull of the Imperial Mammoth," with brief description of its size and anatomy, but with nothing more nearly approaching geographical treatment than the statement that the specimen came from "the sands of western Texas." In all such cases it is open to question whether close scrutiny as to inclusion and exclusion has been given, and while the policy pursued by many geographical societies of generously accepting for their journals many sorts of interesting articles has something to commend it in the way of pleasing a mixed constituency, it is nevertheless open to the objection of not sufficiently advancing the more scientific aspects of geography. Blades of grass and mammoth skulls are very good things, if crops of hay and collections of fossils are to be gathered; but they are in the way of the growth of the best corn and of the publication of the best geographical journals. Let no one suppose, however, that the audiences in geographical lecture halls or the readers of geographical journals need suffer under the scrutiny that is here urged regarding lectures and articles. There is, even under the strictest scrutiny, an abundance of varied and interesting matter of a strictly geographical nature; few if any sciences are richer than geography in matter of general interest. There is indeed some reason for thinking that the real obstacle in the way of applying close scrutiny in the way here recommended, is the difficulty of obtaining high-grade material presented in an essentially geographical form. Inasmuch as this difficulty arises from the relative inattention to geography as a mature science, it is the businss of geographical societies to remove the difficulty.

It has been maintained that one of the embarrassments from which geography suffers is the incoherence of the many things that are involved in its broad relationships. This is not really a serious embarrassment, and so far as it is an embarrassment at all it is not peculiar to geography. It is not a serious embarrassment, because when any element of geography is treated in view of the relations into which it enters, it becomes reasonably interesting to all who are concerned with scientific geography. The embarrassment is not peculiar to geography, for it is found in all other studies; in history, for example,

where an essay by a specialist on the modern history of South America is not likely to excite an enthusiastic interest in the mind of the student of classic times in Greece, or in the mind of the student of mediæval church history in Germany; the embarrassment is known also in geology, where the student of the petrography of the southern Appalachians, or of the paleontology of the Trias in California, may care little for a paper by a colleague on the glaciation of the Tian Shan mountains in Turkestan. Yet, however unlike these various topics in history or in geology may be, they are welcomed, if well treated, by all the members of the expert society or by all the readers of the special journal in which they are presented, because they so manifestly make for progress in the science to which they belong. Geographers need not therefore be embarrassed on finding discussions of magnetic declination as affecting the navigation of the Antarctic regions, of the relations of climate and religion among the Hopi Amerinds, and of the facilities for irrigation peculiar to aggrading fluviatile plains, all in one journal; this diversity of topics only illustrates the great richness of geography, and thus likens it to history and geology.

Let me consider next the advantages that will come to geography from the systematic collection and classification of all the facts pertinent to it. The popular idea of geographical research is fulfilled when an explorer discovers a new mountain or a new island; but discovery is not enough. The thing discovered must be carefully described in view of all that is known of similar things, and the relation into which the thing enters must be sought and analyzed. Careful work of this nature involves the development of systematic geography, in which all items of a kind are brought together, and all kinds of items are arranged according to some serviceable scheme of classification. Geographers are far behind zoologists and botanists in this respect, for there is to-day no comprehensive scheme of geographical classification in general use. Existing schemes are too generally empirical and incomplete. So important a group of land forms as mountains has never yet been thoroughly treated in a physio-

graphic sense, while the organic responses to inorganic controls are as a rule not classified by geographers at all; yet a comprehensive scheme of classification should certainly provide systematic places for the organic responses as carefully as for inorganic controls. In the absence of a generally accepted scheme of classification, it is natural that items of one kind and another should be neglected in text-books and elsewhere; for it is well known that incompleteness of treatment goes with unsystematic methods. So simple and manifest a response to the globular form of the earth as is afforded by the wide extent of modern commerce is seldom mentioned in connection with its control. The many important and interesting responses to the eternal and omnipresent force of gravity are not habitually treated as geographical topics at all; nor is the definition of boundaries in terms of meridians and parallels usually recognized as a response that civilized nations now habitually make to the form and rotation of the earth, when they have occasion to divide new territory in advance of surveys and settlement. Yet surely all these responses to environment deserve systematic mention when the earth is described as a rotating, gravitating globe, just as the location of villages and the growth of cities at some point of advantage to their inhabitants deserves mention in the pages given up to geography of the more conventional kind. The development of a well-tested scheme of systematic geography may therefore be urged upon every geographer as a problem well worthy of his attention. A practical step toward the construction of such a scheme is evidently the accumulation of items that call for classification; therefore, let the geographer study the world about him: and a most effectual aid in the accumulation of items is found in searching for the organic response to every inorganic control, and for the inorganic control of every organic response that comes to one's attention; therefore, let the geographer think carefully as he looks about him over the world. It can hardly be doubted that the explorer who goes abroad or the student who stays at home will make better progress in his investigations in proportion to the completeness of the systematic scheme

with respect to which he consciously carries on his work. I would therefore urge the development of the habits of always associating causes with their consequences and consequences with their causes, and of always referring both causes and consequences to the classes in which they belong. If to these two habits we add a third, namely, that of making a careful arrangement of the classes in a reasonable and serviceable order, we shall have taken three important steps in geographical progress, and, as a result, geography will flourish.

There is no device by which the work of the specialist is so helpfully relieved of its narrowing influence as by the simple device of looking always for the general geographical relations of any special topic. The specialist in the geographical study of ocean currents, of caverns or of deltas, of forests, of trade routes, or of cities, should not lessen his attention to his chosen line of work, but he should, often to his great advantage, increase his attention to the place that his chosen subject holds in the whole content of geography. Not only will his work be broadened in this way, but both he and his work will be brought into closer relations with the whole body of geographers and the whole content of geography, and the possibility of organizing a society of mature geographical experts will be thereby greatly increased. If the geographical relations of a special topic are not looked for, the specialist fails to that extent of becoming a geographer. The climatologist who studies the physical conditions of the atmosphere for their own sake, the oceanographer who makes no application of the physical features of the ocean as controls of organic consequences, the geomorphist who is satisfied with the study of land forms as a finality, the student of the location of cities and the boundaries of states who makes no search for the explanation of his facts as affected by physiographic controls—these specialists may all be eminent in their own lines, but they fall short of being geographers. In the same way it might be shown that a petrographer who makes no study of field relations and discovers no results of processes and no sequences in time, fails of being a geologist, for geology deals essentially with processes and

structures in time sequence; likewise a chronologist who is satisfied with mere dates of occurrence fails of being a historian, for history involves the meaning as well as the mere sequence of human events. There is, of course, no blame to be attached to interest in specialization, no praise to an interest in larger relations; it is merely a matter of fact that the isolated specialist remains somewhat to one side of the larger sciences with which he might become associated. On the other hand, the geographer is not necessarily so broad-minded that he must be shallow; he may specialize deeply on the climatologic, oceanographic, geomorphic, topographic, organic divisions of his subject; but if he wishes to be considered a geographer he should cultivate all the geographic relations into which the facts of his chosen division enters, and he will find that it is largely through these relations that he associates himself profitably with other geographers.

Two of the most beneficial results of the systematic study of geography are the great increase in the number of classes or types with which the geographer becomes familiar, and the great improvement in the definition of these types. This is particularly the case with those types which contain many individual examples, such as rivers and cities, and which are therefore capable of division into many headings. So long as the geographer deals only with things in an empirical fashion, he may be satisfied with a rough classification; as soon as he begins to treat his problems more carefully, his classification becomes more refined and he has relatively more to do with classes of things than with the things themselves. The things are actual, the classes are ideal, and therein lies one of the greatest values of systematic geography; it enforces attention upon the idealized type; by means of this increased attention the type is more fully conceived, and both observation and description of actual things are greatly aided. Let me illustrate.

The breezes that descend from mountain valleys at night are well known and well understood phenomena. As a result, one may form a well-defined conception of such a breeze—a type mountain breeze—imagining its gradual beginning, its

increase in strength with its extension in area, and its gradual extinction; all its phases of waxing and waning being duly related to the passing hours of the night and to the associated changes of temperature. It is safe to say that no actual mountain breeze is as well known by direct observation of all its parts and stages as is the type breeze, in which all pertinent observations are properly generalized, and in which the deficiencies of observation are supplemented as far as possible by inferences deduced from well-established physical laws. It is entirely possible that there may be some errors in the deduced elements of the ideal type-breeze, but it may be confidently asserted that the errors will be replaced by the truth through the methods involved in observing, imagining, and checking, guided by the conception of the type, sooner than the truth will be discovered by blind observation unguided by the aid that a well-defined type affords.

It is the same with an alluvial fan; an element of land form that has, by the way, more similarity to a mountain breeze than appears on first thought. Observation shows only the existing stage of the surface of a fan; the fully developed type-fan includes the structure as well as the surface, the process and the progress of formation, extended into the future as well as brought forward from the past. There can be no question that the explorer who is equipped with a clear conception of a type-fan can do much better work in observing and describing the fans that he may find than will be done by an explorer who thinks he can dispense with all idealized types, and who proposes simply to describe what he sees. The shortcomings of the simple observational method would be less if it were not so difficult to see what one looks at and to record what one sees; but any one who has had experience in field studies knows how far short seeing may be of looking, and how far short recording may be of seeing. The best results in geographical investigation can only be obtained when every legitimate aid to observation and description is summoned; and, of all aids, that furnished by carefully considered types, reasonably classified, is the greatest. When large and complicated features, such as

valley systems or cuestas, are to be described, the need of types is vastly increased. Hence one of the most important and practical suggestions that can be made toward the maturing of geographical science is to cultivate the geographical imagination in the direction of acquiring familiarity with a large, systematic series of well-defined ideal types. As progress is made in this direction there will be profitable advance from that narrow conception of geography which is based on the school-day study of names, locations and boundaries—the only conception of geography that many mature persons in this country possess—to a wider conception in which everything studied is considered as an example of a kind of things, so that it shall appeal to the reasonable understanding rather than to the empirical memory. Progress of this sort is already apparent in the schools, but it has not yet reached a desirable measure of advance.

One of the best results that will follow from the systematic recognition of a large number of well-defined types will be the natural development of an adequate geographical terminology. When review is made of modern geographical articles, it is curious and significant to find only a small addition to the school-boy list of technical terms. This is not true of any subject that is cultivated in the universities as well as in the schools. It is a reproach to geography that the results of mature observation are so generally described in the inadequate terms of immature study; this reproach will have the less ground the more thoroughly systematic geography is studied. With the development of more mature methods of description there may come a larger share of attention to the thing described, and thus a relative decrease of attention to matters of merely personal narrative. I do not wish to lessen the number of entertaining books of travel which now fill many of the shelves in libraries called geographical, but it would be a great satisfaction to see the standard works of geographical libraries given a more objective quality, so that they might compare favorably with the standard works of geological or botanical libraries, in which the element of personal narrative is reduced to its properly subordinate place.

Another step of equal importance with the establishment of geographical types is the change from the empirical to the explanatory or rational or genetic method of treating the elemental facts that enter into geographical relationships. The rational method has long been pursued in regard to the facts of the atmosphere and the ocean; it is coming to be adopted for facts concerning the lands; and since the adoption of an evolutionary philosophy, the evolutionary explanation of the organic items of geography may replace the teleological treatment that obtained in Ritter's time. It is, however, very seldom the case that geographers adopt the rational method consciously and fully; hence special attention to this phase of the theoretical side of geography may be strongly urged. It may be noted in this connection that the application of the explanatory method has been so lately made to the treatment of land forms that the geographer may for the present make himself to his advantage something of a specialist in this branch of the subject. It should be added that, so long as he studies land forms in order better to understand the environment in which living things find themselves, he remains a geographer and does not become a geologist. There is a needless confusion in this matter, which may perhaps be lessened if its untangling be illustrated by the following geological comparison.

For some decades past a new method of treatment has been applied to the study of rocks, greatly to the advantage of geologists. The method requires a good knowledge of inorganic chemistry and of optical physics, and the geologists who have specialized in the study of rocks have had to make themselves experts in these phases of physics and chemistry; but they are not for that reason classified as physicists or chemists. They remain geologists, though sometimes taking the special title of petrographer. So with the geographer who specializes in the study of land forms; he must make himself familiar with certain phases of geology, but he does not therefore become a geologist; he remains a geographer. His object is not to discover for their own sake the past stages through which existing land forms have been devel-

oped; he studies past forms only in order to extend his knowledge of systematic physiography and thus to increase his appreciation of existing forms. As far as he studies the sequence of past forms he is studying a phase of geology, just as the geologist who examines existing arrangements of climate, of oceanic circulation, or of land forms, is studying a phase of physiography. The two sciences are manifestly related, but they need not be confused. For, as has been shown for sciences in general, geology and geography are best characterized by the relations in which their topics are studied and not by the topics themselves. Both are concerned with the earth and life. The whole content of knowledge concerning the earth and life might be shown by a cube, in which vertical lines represented the passage of time, and horizontal planes represented phenomena considered in their areal extension; then if the whole mass of the cube were conceived as made up of vertical lines, that would suggest the geological conception of the whole problem; while if the cube were made up of horizontal planes, that would suggest its geographical aspect; and the whole series of paleogeographies, horizontally stratified with respect to the vertical time line, would culminate in the geography of to-day.

Objection is sometimes made to the plan of geography, as here set forth, that it involves hypotheses and theories, instead of being content with matters of fact, as the advocates of a more conservative method in geography suppose themselves to be. There is no doubt that geographical investigation of the kind here exposed does involve abundant theorizing, but that is one of its chief merits, for therein it adopts the methods of all inductive sciences. Furthermore, as between the progressive geographer, who candidly recognizes that he must theorize, and the conservative geographer, who thinks that he observes facts only and lets theories alone, the chief difference is not that the first one theorizes and the second does not, but that the first one knows when he is theorizing and takes care to separate his facts and his inferences, to theorize logically, to evaluate his results, while the second one theorizes unconsciously and hence uncritically, and therefore fails to separate

his inferences sharply from his facts, and gives little attention to the evaluation of his results. Geography has indeed suffered so long and so seriously from the failure of geographers to cultivate the habit of theorizing as critically as the habit of observing—studies of the atmosphere and the ocean still excepted, as above—that a strong recommendation must be given to the acquisition of the methods of theoretical investigation, in which deduction is an essential part, by every one who proposes to call himself a scientific geographer. Let me give an example of the loss of time that has resulted from the failure of geographers to develop the habit of theorizing.

For forty years past there has been active discussion as to how far land forms in glaciated regions had been shaped by glacial erosion, but not till within five years has any geographer clearly defined the deductive side of this problem. In order to determine whether land forms are carved by glacial erosion or not, two methods have been open: one is to observe the action of existing glaciers and thus determine whether they are competent or not to carve land forms; but this is difficult, because the beds on which glaciers lie cannot be well examined. The other method is to deduce the appropriate consequences of both the affirmative and the negative suppositions, and then to confront these consequences with the facts found in regions once glaciated, and see which set of consequences is best supported. This deductive method is very simple. Its application involves no principle that was not perfectly well known fifty years ago, though it does involve a facility in theorizing that does not seem to have been familiar or habitual with geographers until more recent times. On the supposition that glaciers do not erode, the valley systems of once glaciated mountains ought not to exhibit any significant peculiarity of form, but should correspond to the normal stream-worn valley systems of non-glaciated mountains. On the supposition that glaciers do erode, the valley systems of once glaciated mountains should exhibit the highly specialized feature of a discordant junction of branch and trunk; for the channels eroded by a small branch glacier and by a large trunk glacier must stand at discordant

levels at their junction, just as the channels of a small stream and a large river do, though the measure of discordance is much greater in the channels of the clumsy, slow-moving ice-streams than in the channels of the nimble, quick-moving water-streams. There can be no question that these well specialized consequences, deduced from the postulate that glaciers can erode their channels, are much more accordant with the actual features of valley systems in once glaciated mountains than are the consequences deduced from the opposite postulate; but my reason for introducing this problem here is not to call attention to the value of "hanging valleys" in evidence of glacial erosion, as first clearly set forth by Gannett in 1898 in his account of Lake Chelan, but rather to point out how slow geographers have been to employ the deductive method in solving this long-vexed problem. The moral of this is that geographers as well as geologists, physicists, astronomers ought to have good training in scientific methods of investigation, in which all their faculties are employed in striving to reach the goal of full understanding instead of depending so largely on the single faculty of observation.

Some may, however, object that the problem of glacial erosion, just touched upon, belongs exclusively to geology and not at all to geography. It belongs to both; its association will be determined by its application, as the following considerations will show. The accumulation of sand-dunes by wind action, the abrasion of sea-coasts by waves, the erosion of gorges by streams, the construction of volcanoes by eruptions now in progress, manifestly belong in the study of physical geography, in close association with the blowing of the winds, the rolling of the waves, the flowing of streams, and the outbursting of lavas and gases. Both the agent and the result of its action are elements of the environment by which life is conditioned. Similarly, the grass-covered dunes of Hungary, the elevated sea-cliffs of Scotland, the abandoned gorges of central New York, and the quiescent volcanoes of central France, are all elements of land forms and are all treated as geographical topics and explained by reference to their

extinct causes in the modern rational method of geographical study. Likewise the discordant valley systems of glaciated mountains are proper subjects for explanatory treatment in the study of geography, although the glacier systems that eroded them are extinct; they deserve explanatory treatment in geography just as fully as do the accordant valley systems of non-glaciated mountains. It is true that discussion as to whether certain sculptured land forms are due to glacial erosion is likely to continue more or less actively through the present decade; but when this problem is as well settled as the problem of stream erosion has already been, the geographer will be content with the simplest statement of the evidence that is essential to the conclusion reached; and the explanatory descriptions of land forms will include due reference to forms of glacial origin, just as much as a matter of course as they now include reference to forms of marine or of subaerial origin. Forms of glacial sculpture will be given as assured a place in geographical study as forms of glacial deposition are already given. Neither the thing studied, nor the agent by which it was produced, nor the method by which the agent is shown to be accountable for the thing, suffices to show whether the thing is of a geological or a geographical nature. This question will be decided, as has already been shown, by the relations into which the thing enters. It would be as unreasonable to omit all reference to glacial erosion in a geographical description of Norway as to omit all reference to subaerial erosion in a geographical account of our Atlantic coastal plain.

Nowhere is the cultivation of systematic geography more helpful than in the study of local or regional geography. The truth of this may be appreciated by considering the case of botany. No botanist would attempt to describe the flora of one of our states until he had obtained a good knowledge of systematic botany in general. Such knowledge would help him at every turn in his study of a local flora, not only in describing the plants that he might find, and in arranging the descriptions in a serviceable order, but also in finding the plants themselves. I believe that a closely equivalent statement might be made with regard to the geography of a state;

and yet there is not, to my knowledge, a single work on regional geography in which a recognized scheme of systematic geography has been avowedly followed as a guide for the treatment of local features. The adoption of such a guide would lead to various advantages; on announcing that a certain scheme of systematic geography has been chosen as a standard, the writer of a regional work thereby gives notice in the simplest manner to the reader as to the kind and amount of knowledge necessary to understand the work in hand; descriptions are made at once briefer and more intelligible by phrasing them in terms of a scheme that is elsewhere stated in full; relative completeness of treatment is assured, for with a systematic list of all kinds of geographical relations at hand, the writer is not likely to overlook any element of the subject that occurs within his chosen region; the reader can easily find any desired topic, not only by means of the table of contents and index, but also by means of the standard scheme of classification in accordance with which all elements are arranged; and finally, books on different regions will come to exhibit a desirable uniformity of treatment, when they are based on a common scheme of systematic geography. Although no books of this kind now exist, I do not think it over-venturesome to say that some such books will soon exist, and that they will form very serviceable contributions to the literature of our subject.

The various recommendations that I have made are likely to remain in the air, or at most to secure response only from isolated individual students, unless those who believe that the adoption of these recommendations would promote the scientific study of geography are willing to give something of their time and thought towards organizing a society of geographical experts—an American Geographers Union. From such a union I am sure that geography would gain strength, but it is not yet at all clear in my mind that any significant number of persons would care to accept the strict conditions of organization which appear to me essential for the success of such an enterprise. The most important of the conditions are as follows:

1st. The adoption of some definition for geography that shall sufficiently indicate the boundaries as well as the content of this broad subject.

2d. The limitation of membership to persons with whom geography as thus defined is a first or at least a second interest, and by whom more than one geographical article of advanced grade, based on original observation and study, has been published.

3d. The independence of the union thus constituted of all other geographical societies.

Although we cannot adduce any existing geographical society in this country as a witness competent to prove that geography has sufficient unity and coherence to tempt geographers to form such a union as is here contemplated, a careful review of the problem convinces me that a sufficient unity and coherence really exist in the science as I have here treated it; and I therefore believe that the formation of an American Geographers Union is feasible as well as desirable.

It has been my object in this address to describe briefly the status of mature geography in our country, and to suggest several steps that might be taken for its improvement. Certain branches of the subject have reached a high development, but the subject as a whole does not thrive with us. The reason for its relative failure is not, I believe, to be found in the very varied nature of its different parts, but rather in the failure to place sufficient emphasis on those relationships by which, more than by anything else, geography is to be distinguished from other sciences, and by which, more than by anything else, geographers may come to be united. Among the great number of persons—many thousands in all—whose attention is given primarily to subjects that are closely related to geography as here defined, there must certainly be many—probably several hundred—with whom mature scientific geography is a first interest. It is upon these persons, geographers by first intention, that the future development of sound and thorough, mature and scientific geography among us primarily depends. To these geographers in particular, I would urge

the importance of developing the systematic aspects of the science, and of constantly associating the special branch that they cultivate with the subject as a whole. Observation will not suffice for the full development of geography; critical methods of investigation, in which deduction has a large place, must be employed; for only by the aid of careful theorizing can an understanding of many parts of the subject be gained. With the progress of systematic geography we may expect to see a parallel progress of local or regional geography. As the science is thus developed, societies of mature geographical experts will be formed, and scientific geography will thrive; but whether thus developed into a thriving science or not, I hope that another long term of years may not pass without a representative of geography in this vice-presidential chair.

PAPERS READ.

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The Sudbury Nickel-Bearing Eruptive. By A. P. Coleman.

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Structural Relations of the Granites of North Carolina. By Thomas Leonard Watson.

Field Work in the Wisconsin Lead and Zinc District. By U. S. Grant.

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Postglacial Changes of Attitude in the Italian and Swiss Lakes. By Frank Bursley Taylor.

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COMPARISON OF THE STRATIGRAPHY OF BLACK HILLS, BIG HORN MOUNTAINS, AND ROCKY MOUNTAINS, FRONT RANGE. BY N. H. DARTON.

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ADDRESS

BY

CHARLES W. HARGITT,

VICE-PRESIDENT AND CHAIRMAN OF SECTION F FOR 1903.

SOME UNSOLVED PROBLEMS OF ORGANIC ADAPTATION.

With the advent of the "Origin of Species" became current the naturalistic interpretation of organic nature, epitomized in such phrases as "natural selection," "survival of the fittest," etc. So rapid and general was the acceptance of this conception as a working hypothesis that in thirty years, or within a single generation, Wallace made bold to claim for it universal recognition in the well known and oft-quoted declaration, "He (Darwin) did his work so well that descent with modification is now universally accepted as the order of nature in the organic world."

As a general statement of the fact of evolution, as the phrase may be literally interpreted, it may, after fifteen additional years of intense biological activity, be as vigorously claimed and as readily conceded. If, however, it be so interpreted as to include the full content of Darwinism and the all-sufficiency of natural selection as the prime factor, with its details of endless adaptations to environment, whether physical or physiological, it need hardly be said that consent would be far less general or prompt.

Moreover, with the highly metaphysical and speculative deductions which, under the caption of "Neo-Darwinism," or, more plainly, "Weismannism," which have boldly assumed the omnipotence and all-sufficiency of natural selection to account for the least and last detail of organic differentia-

tion or constancy, widespread doubt and open protest are too common to elicit surprise or comment.

It need hardly be pointed out at this late day, though it is more or less persistently ignored, that primitive Darwinism, while essaying to explain the origin of *species*, and emphasizing the importance of natural selection as a means in the process, did not in the least presume to account for the origin of *variation* and *adaptation*, which were recognized as fundamental and prerequisite in affording conditions without which natural selection must be hopelessly impotent. Nor, moreover, should it be overlooked that while recognizing the inseparable correlation of the factors just mentioned and their essential utility either to the individual or species in the majority of cases, Darwin was free to concede and frank in declaring the efficiency of many other factors in the intricate and complicated problems of organic evolution.

The recent impulse which has come to biologic progress by experimental methods, and the remarkable results which have been attained thereby, may without exaggeration be said to have raised anew many an earlier doubt as well as brought to light problems apparently quite beyond the scope of the older explanations. It may not, therefore, be an extravagant assumption to announce the entire question of organic adaptations as open for reconsideration, in the light of which no apology will be necessary for directing attention to certain phases of the subject upon the present occasion.

Among the many problems which recent investigations and conclusions have brought into better perspective as well as sharper definition, and which might profitably be discussed, the limits of a single address preclude any very wide range of review. I have, therefore, chosen to restrict my discussion chiefly to problems of coloration among lower invertebrates, including incidental references to correlated subjects, and the probable limitations of color as a factor in organic adaptation.

Interesting as it might be to glance at the earlier views of a subject, the nature of which from earliest times must have been a source of keen interest to mankind in general, and

which must have appealed to the æsthetic and rational nature, inspiring not only poetic imagery but admiring awe and a devout fervor akin to reverence, it must suffice in the present discussion to hold attention well within the period of thought immediately concerned, which, as already indicated in the opening prargraph, was brought into prominence by the "Origin of Species."

As is perfectly well known, color in nature is due to one of two causes, or to a combination of both, namely: (1). What has been termed optical or structural conditions, such as diffraction, interference or unequal reflection of light, examples of which are familiar in the splendid hues of the rainbow, the irridescent sheen and metallic colors of the feathers of many birds, wings of insects, etc. (2). What are known as pigmentary colors, due to certain material substances lodged within the tissues of animals or plants which have the property of absorbing certain elements of light and of reflecting others, and thereby producing the sensation of color. While the two are physically quite distinct it is not unusual to find them associated in producing some of the most exquisite color effects of which we have knowledge. In a general way one may usually distinguish between these two sorts of color by noting that those which are purely optical in their character produce a constantly changing impression as the relative position of object or observer may happen to vary with reference to the angle and direction of light; while upon the other hand colors which are due to pigments show this property very slightly or not at all, and that, moreover, pigment colors are usually more or less soluble in various reagents, such as alcohol, ether, acids, alkalies, etc., and that they often fade rapidly under the influence of strong light or in its absence, or upon the death of the organism.

The presence of many and various colors in inorganic nature, the large majority of which are due to purely physical causes, such as the colors of the ocean, the sky, the clouds, the mineral or gem, while appealing to our sense of beauty elicit no special inquiry as to their significance or purpose. It suffices to know that they are constitutional or structural,

inseparable from the physical conditions in which they have their place.

It is different, however, with much of the color found in the organic world. While such colors as those of the grass or leaf might seem to have hardly any different explanation or to call for special explanation different from the preceding, as Wallace has pointed out, on the other hand, as he has also forcefully expressed it: "It is the wonderful individuality of the colors of animals and plants that attracts our attention —the fact that colors are localized in definite patterns, sometimes in accordance with structural characters, sometimes altogether independent of them; while often differing in most striking and fantastic manner in allied species. We are therefore compelled to look upon color not merely as a physical but also as a biological characteristic, which has been differentiated and specialized by natural selection, and must therefore find its explanation in the principle of adaptation or utility."

It is under the stimulus of this conception that the significance of color has come to have the large place and concern in the literature of evolution which it at present occupies, as expressive of which such well known phrases as "protective coloration," "warning colors," "mimicry," etc., have come to be household commonplaces among us. It is not surprising therefore that in a book like Wallace's "Darwinism" out of a total of some four hundred and seventy-five pages more than one hundred and fifty should be devoted to this phase of the problem alone, while it has frequent reference in other connections.

And the same is largely true of much of the literature dealing with the subject of organic colors. In other words, color in these relations has been studied largely, if not wholly, as a factor in adaptation—fitting the animal to better meet the exigencies of life in the struggle for existence, in certain cases serving as a disguise or screen against detection, in others by glaringly advertising some noxious quality, in still others by flying a signal of alarm or warning, and in flight serving to segregate the members of a herd in whose collective aggregate a larger measure of protection might be realized.

Hence it naturally came to pass that color was looked upon largely as a physical factor in the sum total of the animal's morphology which must have some fundamental relation to the adaptation or fitness for survival of the species. It is not strange, under prevailing conditions, that small attention was directed to the more fundamental problem of the *physiological* significance of color, or the part it has to do in the processes of metabolism of the individual organism. Recent work in experimental morphology has directed attention to this phase of the problem, and one of the objects of the present discussion will be to make somewhat more evident a too long neglected aspect of animal biology.

It ought not to be overlooked in this connection that along with the development in experimental morphology to which reference has been made, those of organic chemistry, and particularly chemical physiology, have been perhaps equally important in directing attention to certain phases of our problem. Nor ought we to forget that the spectroscope has thrown its light upon the same general problem, though with perhaps less of conclusiveness than could have been desired. As a result of this growing activity there has been accumulated a body of information, a part of which stands directly related to the subject under consideration, and a part indirectly concerned with the same essential principles, and from it we may safely predict the solution of problems hitherto only predicated hypothetically, and such side-lights upon others equally important that it is not too much to confidently forecast substantial progress all along the line.

It may be well in this connection to glance briefly at some of the results at present known as in some measure justifying these somewhat optimistic assumptions, as well as pointing the line along which important and promising researches may be prosecuted.

The work of Krukenburg, MacMun, Macallum, M'Kendric, Hopkins, Urech, Eisig, Cunningham, and a host of others, comprising a mass of literature of enormous proportions, will be available to those interested and may afford some faint conception of the magnitude and importance of the field to

be explored, as well as an introduction to that already made available. And while as a result of this activity many and various organic pigments have been isolated and their composition in part or entirely made known, it must be recognized that the task of the chemical analysis of any such highly complex compounds as most of these are known to be is attended with extreme difficulty and no small measure of uncertainty. Still, it has been possible to fairly distinguish several classes of such pigments, differentiated physiologically as follows:—

First.—Those directly serviceable in the vital processes of the organism. Under this head may be classed such pigments as hæmoglobin, chlorophyll, zoonerythrin, chlorocruorin, and perhaps others less known. It need not be emphasized that by far the most important of these are the two first named. The others, found chiefly among the lower invertebrates, are believed to serve a function similar to the first.

Second.—Waste products. Among these the several biliary products are too well known to call for special note. Guanin is a pigment of common occurrence in the skin of certain fishes and is associated with the coloration of the species. Similarly certain coloring matters have been found in the pigments of many lepidoptera, known as lepidotic acid, a substance closely allied to uric acid and undoubtedly of the nature of a waste product.

Third.—Reserve products. Of these there are several series, one of which, known as lipochrome pigments, is associated with the metabolism involved in the formation of fats and oils. Perhaps of similar character are such pigments as carmine, or rather cochineal, melanin, etc. It may be somewhat doubtful whether these pigments do not rather belong to the previous class, where should probably be listed such products as hæmatoxylin, indigo, etc., etc., all of which have been claimed as resultants of destructive metabolism in process of being eliminated from the physiologically active tissues of the body of the organism. Of similar character is probably tannic acid, a substance well known among plant

products and involved in the formation of many of the brownish and rusty colors of autumn foliage, particularly of the oaks and allied trees, as are the lipochromes in the formation of the reds and yellows which form so conspicuous a feature among autumn colors.

While the association of these and other pigmentary matters has long been known in connection with both animal and plant growth, and while the conception of their more or less intimate relation to the active metabolism of the various tissues is not new, comparatively little has been done toward directly investigating and elucidating the exact nature and extent of the process. This seems to be especially the case in relation to the part played by these products in the formation of those features of coloration among organisms with which we are now concerned.

The most strenuous advocates of the primary importance of natural selection as the chief or only factor in adaptation are free to admit that among the simplest forms particularly, color has originated in some more or less obscure way through growth or some of the vital activities of the organism, Darwin, for example, merely suggesting that "Their bright tints result from the chemical nature or minute structure of their tissues," and Wallace in the even less explicit statement that "color is a normal product of organization," whatever that may imply.

So far as I am aware Eisig was among the earliest to claim that among certain annelids the colors were primarily expressions of the katabolic processes of the tissues, and were excretory in character. He was able to largely demonstrate this with species of Capitellidæ by experimental methods. By feeding the animals with carmine he was able to follow its course through the alimentary tract, its progress through the tissues, and final deposition in the hypodermal tissues beneath the cuticle, where in the process of moulting it was finally eliminated. He also found that in a species of Eunice, which fed upon sponges, the pigment granules of the food passed unchanged through the intestine and into the body tissues much as had been the case in the experiments with the preceding.

Graff later reached very similar conclusions concerning coloration in the leeches, but was able to go a step farther than Eisig had done and to show in great detail the exact process through which it was brought about. He found in the endothelium certain migatory cells which wander about in the cœlom or penetrate through the tissues, and that among their functions one of the most important seems to be the absorption of foreign bodies and their conveyance into the mouths of the nephridia or through the tissues to the hypodermis and their lodgment in that tissue. He was even able to show that the special markings or color patterns which are so characteristic in some of the animals may be explained by the disposition of the muscle bands, and their relation to the lines of pigmentary deposition by the wandering cells, which Graff has designated "excretophores." He was also able to confirm the results of Eisig as to the experimental demonstration of feeding with various pigmentary matters, and subsequently tracing them from point to point in the process of elimination. Furthermore he showed that the amount and density of pigmentation was closely related to the intensity of metabolism, being greatest in those specimens which were most voracious feeders.

Observations of a similar character have been made upon certain of the Protozoa, particularly upon Stentor. Schuberg in 1890 found that the blue-green pigment so characteristic of this organism was constantly being excreted bodily in the form of definite granules.

In 1893 Johnson, in an extended study of the morphology of these Protozoa, confirmed the preceding observations, and showed that the pigment was excreted along with other excrementitious matter. He found also that the principal region of excretory activity was at the base of the animal, where was formed after a short time a definite mass of debris near the foot.

Perhaps one of the most important contributions along this line is that of Harmer on the character of the "brown body" of the Polyzoa. By a series of critical observations upon the life-history of these interesting organisms, and painstaking

experiments in feeding with carmine and other pigments, he was able to prove beyond reasonable doubt that the so-called "brown body" of the Polyzoa is a direct product of the destructive metabolism within the body and is excreted in a mass at this particular region. He found that the leucocytes of the funicular organ as well as certain cells of the organ itself engulfed pigmentary wastes, and with the periodic decline of the polypides these cells became crowded into a close mass thereby constituting the "brown body." The new polypide arising by a sort of regenerative process was found to be always devoid of any coloration, no pigment appearing for some time following the activity of the new polypide, but that it is formed in regularly increasing amounts with the age and degree of metabolism of the organisms.

Correlated with these views concerning the origin of certain colors and their disposition in the organism is that of the relation of coloration to the food. It has long been known that in many cases there is a more or less intimate relation of color to the food consumed by certain animals. Instances of this are too numerous for detailed consideration here. Let it suffice that Darwin, Semper, Eimer, Koch, Beddard, Poulton, Gunther, and many others, have, by extended observations and by detailed experimentation, apparently established the general fact. Beddard quotes the following observation made by G. Brown-Goode as to such an explanation of protective coloration in fishes. "On certain ledges along the coast of New England are rocks covered by dense growths of scarlet and crimson seaweeds. The cod-fish, the cunner, the sea raven, the rock eel, and the wrymouth, which inhabit these brilliant groves, are all colored to match their surroundings; the cod, which has naturally the lighter color, being most brilliant in its scarlet hues, while others whose skins have a large and original supply of black have deeper tints or dark red and brown." He then quotes farther the suggestions of Goode that these colors are due to pigment derived either directly or indirectly from the red algæ; those which are carnivorous feeding upon the crustacea and other marine organisms whose stomachs are full of the algæ and their pigments which pass unchanged into the tissues of the fishes.

He also quotes a similar conclusion of Gunther as to the origin of the red pigment of the salmon being derived from the red pigment of the crustacea upon which it feeds. While admitting that in the cases just cited there has been no attempt at demonstration of the proposed explanation, it yet would seem highly probable. "It is too remarkable a coincidence that the fish normally with but little pigment should when among these weeds be *bright red*, and that the fish normally possessing black pigment should be *dark red*, to permit of a settlement of the question off-hand by the easy help of natural selection—without at least some further inquiry."

With the foregoing considerations concerning the general origin and development of pigments and their relations to the colors of organisms, we may next proceed to pass rapidly in review such groups of animals as we may choose to consider, and may institute a brief inquiry as to the significance of their types of coloration as factors of adaptation.

With the avowed purpose of restricting my observations and discussion as far as practicable to the lower groups of invertebrates as already announced, it will suffice to say further that in justification of such a course I am constrained to consider the lower animals, particularly Cœlenterates, as more favorable subjects from which to obtain fundamental conclusions than are the more highly specialized insects or birds which have had so large a measure of attention in earlier investigations along these lines.

Furthermore, it seems highly probable that future investigations will involve more of direct experimentation than has hitherto been the case, and if so, these lower series will naturally afford some of the best material available for such inquiries, not only because of the more ready and rapid responses obtained, but from the relative simplicity of their organization and the consequent simplicity of results likely to be obtained in each case.

If further warrant were demanded for a comparatively limited survey, or special emphasis upon a limited group of animals, I should find it in a measure in the personal interest

and familiarity which has come from special researches connected therewith.

Beginning with the Hydrozoa it may be noted in the outset that though including the simplest of the Cœlenterates we shall find a remarkable variety and range of coloration. Among the hydroids, as is well known, coloration is neither very remarkable as to brilliance nor distribution. Many, if not most, are almost without color distinction, except in the dull brownish or amber colors found in such as Obelia, Halecium, and other campanularians. This may be due in part to the fact that the colonies are so generally encased within a chitinous perisarc which, while somewhat colored as already indicated, is seldom if ever of any considerable brilliance or diversity. Among the Tubularians, in many of which the development of a perisarc is slight, and always lacking over the hydranth itself, there is often found considerable coloration, as in Eudendrium, Pennaria, Corymorpha, and others. And in these color is usually found associated more particularly with the development of the sexual products, or during the season of reproductive activity, which is a matter of considerable significance, to be taken up in a latter connection.

As is well known, the predominance of alternation of generations in these animals brings into prominence the sexual phase, which in most species is an independent organism—the medusa. And it is in connection with the medusæ that we find the most marked development of color. There does not, however, appear to be any well-defined distribution of colors into patterns. Among the Hydromedusæ the distribution of pigment, which is almost the only conspicuous kind of color present, is chiefly in association with the gonads, the tissues of the stomach and the regions of the chymiferous canals, though in some cases also extending to the tentacles and in the regions of the sensory organs. It should not be overlooked, however, that in many of these medusæ the color tints are among the most beautiful and delicate known, though lacking the intensity more common among the Scyphomedusæ and corals.

Turning attention to the Scyphomedusæ we find as just

suggested a more copious development of color and also what is more significant, in many cases its distribution into something like definite patterns, as is more or less evident in such genera as Cyanea, Pelagia and Rhizostoma. It is, however, no less evident that among these we have, as in the former, the deposition of pigment along the lines of most active metabolism, such as the gastrovascular and reproductive organs, in most abundance and usually of greatest brilliance.

It is, however, when we come to the Anthozoa, which includes the corals, actinians, sea-fans, etc., that we find the climax of coloration, both as regards brilliance and intensity. To look into the crystalline depths of the waters about a coral reef where these varied forms thrive in great garden-like areas is to gaze upon a scene, the fairy-like features of which it would be difficult to exaggerate. Here are actinians, corals, sea-fans, sea-feathers, etc., etc., which abound in the richest profusion and endless variety, seeming to vie with each other in the effort to produce the most exquisite displays of every tint of the spectrum, in contributing to the splendor of the ocean garden of which they are parts.

In the distribution of color there is not apparently any advance as to differentiation over that found in the Scyphomedusæ, if indeed as much, though among the actinians certain stripings and mottlings occur over the exterior of the body. It is worthy of note that in those forms in which the tendency toward definite coloration is more evident there appears also to be in many cases considerable variation of coloration. This is particularly noticeable in such forms as Metridium and Cyanea.

Face to face with this rich profusion and beauty of color what is its significance? How has it originated and what does it mean? Is it simply the expression of some original constitution peculiar to the entire class, and if so why does it differ in so marked a degree among the different sub-classes? We may safely dismiss such an alternative as altogether unnecessary and without value as an explanation. May it be considered as an adaptation to protection, the result of natural selection? Certainly in no direct sense,

for without exception so far as I am aware the more brightly colored forms are thereby rendered correspondingly more conspicuous and therefore more liable to attack from enemies. May it come within the category of "warning" coloration, due to the offensive cnidarian armor borne by most of the members of this phylum? So not a few who have essayed an account of the matter would have us believe. It seems to me, however, open to serious doubt, aside from the fact that it lacks evidence. On the other hand among hydroids I have found that those having brighter colors are most liable to be eaten by fishes in the habit of feeding upon such a diet. Furthermore various worms, snails, etc., which are known to feed upon them would be more likely to be attracted by colors than to be repelled. It is also matter of common observation that such animals are much more abundant among colonies of highly colored hydroids like Eudendrium, Pennaria, and Tubularia than among species of Obelia or others of little color distinction. Many fishes with finely adapted dental apparatus are constant feeders upon corals, tranquilly browsing among the animated foliage of this luxuriant forest.

Finally, may it come within the category of "sexual selection"? So far as I am aware no one has ventured to assign to it any such a significance. Where sex characters are so little differentiated as among at least a portion of the phylum such an explanation would be as far-fetched as it would be unnecessary. While upon the part of some of the older naturalists there was a disposition to regard the massing of members of the Scyphomedusæ at certain times as having a sexual meaning, it may be doubted whether it has any considerable support in facts.

Concerning coloration among the Anthozoa, Duerden, whose work on the group is so extended and so favorably known, has summarized the following account:

"The prevalence of the yellow and brown color is easily understood when an examination is made of the polypal tissues. For in all instances in which it occurs, the entoderm is found to be crowded with the so-called 'yellow cells' or

Zooxanthellæ, which are unicellular, symbiotic algæ, the chromatophores of which are yellow or yellowish green. That these are the main cause of the external coloration may be easily proved from colonies of Madrepora. In this genus the polyps toward the apex of branches are nearly colorless, and on a microscopic examination of the entodermal layer Zooxanthellæ are found to be absent while they are present in abundance in older pigmented regions."

These symbiotic algæ are not, however, the only source of color among the corals. Duerden finds ectodermal pigment granules, aggregated in somewhat irregular, isolated patches in some cases, in others somewhat regularly distributed.

He also found that a third source of coloration among corals was the presence of what he has termed "boring algæ." These were both red and green, and penetrate into the skeletal mass and color it a distinct red or green, as one or the other may be present.

In his work on the Actiniaria of Jamaica, this author has found in many cases the presence of unicellular green algæ growing upon the surface and giving to the polyp a distinctively green color. He found also superficial granular pigments in certain species which could be removed by any erosion of the ectoderm. I have found the same in several species of New England actinians, and in some cases the pigmentation was irregularly distributed, sometimes in blotches, sometimes in longutidinal stripes, more often the latter. So extremely variable is the coloration in many of these organisms that it is impossible to utilize it as a factor in differentiating species. Duerden has called attention to this feature among both corals and actinians, and believes it to be due to the presence or absence of greater or less intensity of light, and believes it to be an expression of the fact that the Zooxanthellæ are not able to thrive except under proper light, and that, moreover, where light is too intense, as in shallower waters, certain dark pigment found in such specimens is thought to be due to its utility as a screen. While there may be a measure of credibility as to phases of this view, it does not seem to me as of general adequacy. The

variability of species to which I have just referred and to the very common genus Metridium is certainly not due in any appreciable degree to the factor of light, since it occurs indiscriminately among specimens taken in identical situations as well as under those of differing conditions.

In this connection may be mentioned the same phenomenon among medusæ. The variation of coloration in Cyanea has long been known and is so marked that the elder Agassiz distinguished two additional species chiefly on this character, both of which have long since been discarded. It is quite well known to observers that these animals when placed in aquaria usually show within a very short time a more or less marked diminution in colors. Dactylometra while living fairly well for many days in the aquarium loses within this time so much of its usually bright coloration as not to seem like the same creature. The same is true of many other animals than medusæ. On the other hand it is equally well known that many other animals may be placed under these more or less artificial environments with little apparent loss in this or other respect. That it is not due to light alone is evident in the fact that similar changes occur in medusæ which have been kept in open pools or enclosures about docks or elsewhere.

It seems to me rather that the true explanation is to be found in the changed conditions of nutrition and the consequent change in the metabolism of the animal. Hydroids placed under these conditions show the same tendency.

Those which take kindly to the change show no appreciable decline as to color or other vital process. The same is true of medusæ. Gonionemus may be kept for weeks in the aquarium, and if properly fed will show no decline in color, while if the conditions become bad an immediate change is noticeable in this as well as other features.

The same may be said concerning the actinians. While many seem to suffer noticeably when placed in aquaria others show no apparent difference. Cerianthus membranaceus, one of the finest of the actinians to be seen in the Naples aquarium, and one of the most variable, shows no apparent decline in

any vital function. Specimens have been kept in flourishing condition in the aquarium for several years and show no sign of decline, the coloration continuing as brilliant as in the open sea. The same is true of many other organisms found in finest conditions in this celebrated aquarium. Among the annelids Protula soon shows decline in color vigor, and the same is true, though to a less degree, in the case of Spirographis and Serpula.

While it may not be without probability that some measure of this color change may be due in certain cases to the changed conditions of light, it still remains true, I believe, that light alone is but a single factor, and that often a minor one involved in the changes observed, and that changed conditions of nutrition and metabolism are by far the more important.

The main factor of our problem, however, is still unsolved. What answer shall we make to ourselves concerning the significance of the multiform colors more or less general among members of the Cœlentera? It seems to me more or less evident that natural selection can have at best but a limited place in its explanation. I see no place for it along the lines of protection, either direct or indirect.

Of even less significance can any modification of it under the guise of sexual selection be claimed; for even aside from the large majority of cases where there is slight if any sex differentiation, no sensory organization, which Darwin recognized as essential to the exercise of this factor, is present through which it might become operative in even the smallest degree.

Two, and only two, other methods of explanation have seemed to me to afford a reasonable account. First, that it is due primarily to the normal course of metabolism, during which color appears as one of its many expressions. Darwin himself was not indifferent to this possibility, and expressly states in connection with the same problem that color might very naturally arise under such conditions. "Bearing in mind," he suggests, "how many substances closely analogous to organic compounds have been recently formed by chemists, and which exhibit the most splendid colors, it would have

been a strange fact if substances similarly colored had not often originated, independently of any useful end thus gained, in the complex laboratory of the living organism." It has also been pointed out in an earlier portion of this paper that Wallace had to appeal to a similar source in his search for the primary factors of animal coloration.

Geddes and Thomson in discussing the problems of sex likewise make a similar claim. They declare, "pigments of richness and variety in related series, point to pre-eminent activity of chemical processes in the animals which possess them. Technically expressed, abundant pigments are expressions of intense metabolism." They further find in the phenomena of bright colors among the males of most of the higher animals simply the expression of the correspondingly greater activities of the processes of metabolism.

I believe that in this source we have a real account of a considerable body of color phenomena among the lower invertebrates, and particularly of that series under present consideration.

The second factor to which I would appeal is so nearly related to the former as to be involved more or less intimately therewith. It is to the effect that certain pigments are products of waste in process of elimination. This has already been referred to in a former connection and need not be separately emphasized apart from the concrete cases to which it may be applied.

Strongly significant of the importance of this process among the Hydrozoa is the fact already pointed out that pigments are found deposited along the lines of principal metabolism, namely, the gastrovascular regions, the gonads, and to a less extent the immediate regions of sensory bodies, when these may be present. While this alone as a mere statement of fact does not prove the point at issue, when taken in connection with other facts of a similar nature, it amounts to a high degree of probability.

What evidence have we that in the case of hydroids, medusæ, etc., colors are associated with excretory processes? While the facts are not numerous, they are I believe rather convincing.

In work upon regeneration in hydroids, Driesch and Loeb called attention to certain pigmentary matters found in Tubularia and claimed for it an important function in the regenerative process. Morgan, and later Stevens, working upon the same hydroid, became convinced that the claims of the former investigators as to the importance of this pigment were not well founded. They found that not only was the pigment of no special importance, but that it was *really* a waste product, and that during the process of regeneration was actually excreted and finally ejected bodily from the hydranth. I have personally been able to confirm these results on the same and related hydroids, and have also shown that in regenerating medusæ there is formed *de novo* in each regenerating organ, such as manubrium, radial canals, etc., the characteristic pigment of the normal organ. This was particularly noticeable in the case of radial canals. Following their regeneration and promptly upon their functional activity the deposition of pigment made its appearance, and within a comparatively short time had acquired the normal intensity. This was also true of other organs, tentacles and tentacular bulbs, as well as manubrium and canals.

Substantially the same results have been obtained, though here first announced, in experiments upon one of the Scyphomedusæ. In very young specimens where the tissues are delicate it is possible to note the intense activity in regenerating organs, such as sensory body. The first part of this organ to make its appearance is the sensory papilla, which is soon followed by the otoliths, and later by the special pigmentation of the entire organ.

From the foregoing considerations three things seem to me to be more or less evident:

First.—That in all regenerative processes a very marked degree of metabolism is involved, whether in the mere metamorphosis of old tissues into new, or in the direct regeneration of new tissues by growth processes, both of which seem to occur.

Second.—That in regenerative processes there is often associated the development of pigmentary substances which seem to have no direct function in relation thereto.

Third.—That in many cases there follows a more or less active excretion and elimination of portions of the pigment in question.

Concerning color phenomena among the several classes of worms we are in much the same uncertain state of mind as in the former. For while in some of the annelids there may be found fairly well developed visual organs it may be seriously questioned whether they are of any such degree of perfection as would enable their possessors to distinguish small color distinctions. And if this be the case there would at once be eliminated any possibility of conscious adaptation in seeking a suitable environment, or such as would be involved in so-called sexual selection.

Furthermore, it is very well known that among this group some which exhibit among the richest of these color phenomena have their habitat in seclusion, buried in sand or mud, or hidden beneath stones, or with tubes built up from their own secretions, or otherwise so environed as to render practically nil the operation of natural selection.

Again, it should not be overlooked in this connection that in many of the annelids, as well as others, the most pronounced source of color is to be found in the hæmoglobin dissolved in the blood, and that it would be as futile to ascribe its color to natural selection as it would to claim a similar explanation of the color of the same substance in the blood of vertebrates, where as color it is absolutely of no selective value, except in such special cases as the colors of the cock's comb, where it may come to play a secondary function as a sex character.

What shall be said of such forms as Bipalium and Geoplana among land planarians, which exhibit in many cases brilliant coloration, but since they are chiefly nocturnal in their habit and conceal themselves during the day under logs or other cover, the color could hardly serve any selective or adaptive function?

The same is equally true of such forms as Nemerteans whose habitat is beneath the sand along the tide line or below, and also of many annelids having a similar habitat. Some of these, particularly among the latter, have types of coloration

which are often of brilliant character and splendid patterns, vying, as one writer has expressed it, "with the very butterflies."

It cannot be questioned that in some cases we find among these forms what would seem at first sight to be splendid illustrations of protective coloration. If, however, we trace in detail their distribution and variable habitat we shall often find, as did Semper in the case of Myxicola, that the supposed case of marvelous mimicry resolves itself into merest coincidence. This case cited by Semper is described in detail in "Animal Life," and its careful study by some of our over-optimistic selectionists would prove a healthy exercise, conducing to a more critical scientific spirit and, as a consequence, to saner interpretations of appearances in the light of *all* the facts.

The mimicry in the case was of coral polyps among which the annelid was found growing and which, in the form of its branches, their size and coloration, seemed so perfect that it had long escaped notice and was described by Semper as a new species.

It was found in various localities among the corals, but invariably having precisely the same simulation of the polyps, so that Semper noted it as among the finest cases of mimicry which had come to his attention. It so happened, however, that soon after he happened to discover his mimetic Myxicola growing upon a sponge whose color and form were so different as to render it very conspicuous. A systematic search for it in other situations soon revealed it among the rocks, and in his own language, "Almost everywhere, and wherever I examined it carefully, it was exactly of the size and color of the polyps of Cladocora cæspitosa."

Attention has already been called to Eisig's account of coloration among the Capitellidæ, in which he discards the factor of natural selection as wholly inadequate in the case of the organisms under consideration as well as in many others, and refers to many investigators who have likewise found it deficient. In his exhaustive monograph the subject is discussed in considerable detail and references given which it would be impracticable to cite in such a review as the present.

It will be possible to refer but briefly to another group or two in the present discussion, the first of which is the Echinoderms, and chiefly the starfishes. As is well known these organisms exhibit a considerable range of variety and richness of coloration, among which red, orange, brown, yellow and black are more or less common. In not a few cases of course the colors comprise combinations of two or more of those named. An examination has been made of these pigments in a few cases and has sufficed to show that for the most part they are lipochromes, and therefore belong to either reserve or waste products. Similar colors are also found among the brittle-stars, with occasional admixtures of blue or green, colors less common in the former group.

As is also well known similar colors are found among the Crustacea, into a consideration of which it is impossible to enter here. There is a matter, however, which I cannot ignore in connection with the group, namely, the rather remarkable fact that in two phyla having so little in common as to habit, structure or environment, there should be so striking a color resemblance. This is further heightened by the fact that while the one is a prey to almost every denizen of the sea of predatory habit, the other is almost correspondingly exempt. So far as I know Echinoderms have few enemies, and are of course largely invulnerable against such as might otherwise find palatable feeding among these sluggish herds. If the color is in the one case protective, why not in the other? Or if it be not protective on the other hand, why claim such in the first? That sexual selection might have some place among Crustacea may not seem improbable. But if color is its signal here what does it imply among Echinoderms, where in the nature of the case it must be ruled out of account?

Discussing the significance of colors among the Echinoderms Mosely submits the following interesting problem: "Those coloring matters which, like those at present under consideration, absorb certain isolated areas of the visible spectrum, must be considered as more complex, *as pigments*, than those

which merely absorb more or less of the ends of the spectrum. . . . It seems improbable that the eyes of other animals are more perfect as spectroscopes than our own, and hence we are at a loss for an explanation on grounds of direct benefit to the species of the existence of the peculiar complex pigments in it. That the majority of species of Antedon should have vivid coloring matters of a simple character, and that few or only one should be dyed by a very complex one, is a remarkable fact, and it seems only possible to say in regard to such facts that the formation of the particular pigment in the animal is accidental, *i. e.*, no more to be explained than such facts as that sulphate of copper is blue."

Considered from the standpoint of metabolism such facts would hardly seem to assume the difficulty which might be implied in the case just cited, indeed they are in perfect alignment with what might be anticipated, and what has in cases previously cited been found to be actually occurring.

Similar conditions as to color and color significance are also matters of common knowledge in relation to Mollusca. Perhaps few groups among animals exhibit more brilliant and varied colors than are to be found among Gasteropods, yet in many of them this factor can have no more value as a means of adaptation than do biliary pigments or Hæmoglobin among vertebrates, where as pigments their significance is nil. Of them, Darwin with his usual frankness, has said, as previously cited, "These colors do not appear to be of any use as a protection; they are probably the direct result, as in the lowest classes, of the nature of the tissues—the patterns and the sculpture of the shell depending on its manner of growth." Referring in the same connection to the bright and varied colors of Nudibranchs, he further declares, "many brightly colored, white, or otherwise conspicuous species, do not seek concealment; whilst again some equally conspicuous species, as well as other dull colored kinds, live under stones and in dark recesses. So that with these nudibranch molluscs, color apparently does not stand in any close relation to the nature of the place which they inhabit."

Into the classic shades afforded by the insecta as a fruitful

haunt and stronghold of natural selection I must not venture. Not that its problems have all been solved, nor that some considered as settled beyond controversy may not have to be readjusted, not excepting the much exploited Kalima itself, but out of pure regard for the exigencies of the occasion.

No more dare I presume to enter the abysses of the deep sea and to pass in review its manifold and almost untouched problems of color significance, great as is the temptation and attractive as are its inducements. It must suffice to suggest that had half the ingenuity which has been exercised to bring these problems into alignment with the general sway and supposed supremacy of natural selection been employed in an analysis of the pigments and some efforts made to discover the origin of coloration and its general significance as a physiological, rather than as a physical one, we should have been saved the sad rites attending the obsequies of still-born hypotheses and half developed theories. The desperate attempt to save natural selection from drowning in its submarine adventures by lighting its abyssal path with the flickering and fitful shimmer of phosphoresence was worthy of a better cause. It is difficult to be serious with this phase of a subject the nature of which demands anything but ridicule or satire. But the attempts to illuminate the quiescent abysses with the dull glow which under all known conditions requires, if not violent, at least vigorous stimulus to incite it, and the assumption that its sources were sufficient to meet even a moiety of the necessities involved, makes a draft upon one's credulity which might arouse either indignation or the sense of the ludicrous, depending upon the point of view! But seriously, such a conception apparently loses sight of too many evident known conditions of phosphoresence with which we are familiar, not to mention the growing belief that the phenomenon is in itself of the nature of one of the wastes of metabolism, to justify the herculean attempt to make it serve a cause so desperate.

As a concluding word allow me to say that in the present review I have not in the least sought to ignore or discredit the value of natural selection as a factor in organic evolution.

Nor would I be understood as wholly discarding color as a factor in organic adaptation, particularly among the higher and more specialized forms. At the same time I must submit to a growing conviction that its importance has been largely overestimated, and that other factors have been as largely lost sight of. If the present discussion may serve in even the smallest degree to direct attention to some of the latter it will have served its chief purpose.

PAPERS READ.

[Titles preceded by an asterisk were presented by Section F, others by the Central Branch of the American Society of Zoologists, in joint session.]

*THE ALBATROSS ROOKERIES ON LAYSAN. BY C. C. NUTTING.

A RESTRICTED HABITAT OF SCUTIGERELLA IMMACULATA (NEWPORT), TOGETHER WITH SOME REMARKS ON THE ANIMAL AND ITS HABITS. BY S. R. WILLIAMS.

ON THE ANALOGY BETWEEN THE DEPARTURE FROM OPTIMUM VITAL CONDITIONS AND DEPARTURE FROM GEOGRAPHIC LIFE CENTERS. BY C. C. ADAMS.

*A FEATURE IN THE EVOLUTION OF THE TROTTING HORSE. BY F. E. NIPHER.

FURTHER OBSERVATIONS ON THE BREEDING HABITS AND ON THE FUNCTION OF THE PEARL ORGANS IN SEVERAL SPECIES OF EVENTOGNATHI. BY JACOB REIGHARD.

*PHOTOTAXIS IN RANATRA. BY S. J. HOLMES.

*STUDIES ON PROTOPLASMIC STRUCTURE. BY A. W. GREELY.

AMITOSIS IN THE EMBRYO OF FASCIOLARIA. BY H. L. OSBORN.

*On the Morphology of Artificial Parthenogenesis in the Sea-urchin, Arbacia. By S. J. Hunter.

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*Biological Interpretation of Skew Variation. By Frank E. Lutz.

The Correlation of Brain Weight with other Characters. By Raymond Pearl.

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*The Relation between the Law of Ancestral Heredity and Mendelianism. By Frank E. Lutz.

Evolution without Mutation. By C. B. Davenport.

---

*Studies in Compensatory Regulation. By Charles Zeleny.

Iridescent Feathers. By R. M. Strong.

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*Study of Cross-sectional Courses through the Brain with Cortex Surface Relations by Aid of Fuller Sections and Models. By Charles H. Hughes.

The Morphology of the Vertebrate Head from the Viewpoint of the Functional Divisions of the Nervous System. By J. B. Johnston.

The Vascular System and Blood Flow in Diplocardia communis Garman. By Frank Smith and J. T. Barrett.

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*The Diffusion of North American Hawk Moths. By F. M Webster.

*Insect Life above Timber Line in Colorado and Arizona. By Francis H. Snow.

---

*The Salmonidæ and Thymallidæ of Alaska. By Barton W. Evermann.

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*Preliminary Description of a New Family of Gymnoblastic Hydroids from the Hawaiian Islands. By C. C. Nutting.

The Development and Relationships of the Rugosa (Tetracoralla). By J. E. Duerden.

Demonstration of Preparations made during a Study of the Life-history of the Cestode Crossobothrium laciniatum (Linton). By W. C. Curtis.

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*The Types of Limb Structure in the Triassic Ichthyosaurs. By John C. Merriam.

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*A New Group of Marine Reptiles from the Upper Triassic of California. By John C. Merriam.

An Anomaly in the Arterial System of the Dog. By John C. Brown.

The Brain and Nerve Cord of Placobdella pediculata. By H. F. Nachtrieb.

The Mechanism of Feeding and Breathing in the Lamprey. By Jean Dawson.

*Some Reactions of Mnemiopsis leidyi. By Geo. W. Hunter.

---

*Mouth Parts and Oviposition of Gall-producing Insects. By M. T. Cook.

---

*The Bermuda Biological Station for Research. By E. L. Mark.

---

*A Theory of the Histogenesis, Constitution and Physiological State of Peripheral Nerve. By Porter E. Sargent.

---

*The Two Chief Faunæ of the Earth. By Alphеus S. Packard.

SECTION G.

BOTANY.

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PAPERS READ.

[The Mycological Society and the Botanists of the Central States met conjointly with Section G.]

THE WORK OF THE YEAR 1903 IN ECOLOGY. BY H. C. COWLES.

NOTES ON THE BOTANY OF THE CAUCASUS MOUNTAINS. BY C. E. BESSEY.

THE CYPRESS SWAMPS OF THE SAINT FRANCIS RIVER. BY S. M. COULTER.

ECOLOGICAL NOTES ON THE ISLANDS OF BERMUDA. BY S. M. COULTER.

A LICHEN SOCIETY OF A SANDSTONE RIPRAP. BY BRUCE FINK.

RELATION OF SOIL TO THE DISTRIBUTION OF VEGETATION IN THE PINE REGION OF MICHIGAN. BY B. E. LIVINGSTON.

RESEARCH METHODS IN PHYTOGEOGRAPHY. BY F. E. CLEMENTS.

ENSAYO PARA LA FORMACION DE UN FOTO-HERBARIO BOTANICO Y MEDICO DE LA FLORA MEXICANA. BY FERNANDO ALTAMIRANO.

THE ALAMOGORDO DESERT. A PRELIMINARY NOTICE. BY T. H. MACBRIDE.

The Flora of the St. Peter Sandstone in Iowa. An Ecological Study. By B. Shimek.

An Ecologically Aberrant Begonia. By Wm. Trelease.

Plant Formations in the Vicinity of Columbia, Mo. By Francis Daniels.

The Distribution of Some Iowa Plants: Formations on which they Occur. By L. H. Pammel.

The Chemical Constituents of a Soil as Affecting Plant Distribution. By S. M. Tracy.

Vegetation of the North Shore of Lake Michigan. By C. MacMillan.

Zones of Vegetation About the Margin of a Lake. By W. J. Beal.

The Genus Harpochytrium: its Development, Synonymy and Distribution. By G. F. Atkinson.

The Phylogeny of the Lichens. By F. E. Clements.

The Necessity for Reform in the Nomenclature of the Fungi. By F. S. Earle.

Taxonomic Value of the Spermogonium. By J. C. Arthur.

PROOF OF THE IDENTITY OF PHOMA AND PHYLLOSTICTA ON THE SUGAR BEET. BY GEO. C. HEDGECOCK.

CRATERELLUS TAXOPHILUS. A NEW SPECIES OF THELEPHORACEÆ. BY C. THOM.

THE FUNGI CULTIVATED BY TEXAS ANTS BY A. M. FERGUSON.

SYMBIOSIS IN LOLIUM. BY E. M. FREEMAN.

TYPE OF THE GENUS AGROSTIS. BY A. S. HITCHCOCK.

THE MORPHOLOGY OF ELODEA CANADENSIS. BY R. B. WYLIE.

PROTHALLIA OF BOTRYCHIUM OBLIQUUM. BY H. L. LYON.

THE LIFE HISTORY OF EPHEDRA TRIFURCA. BY W. J. G. LAND.

THE EFFECT OF CHEMICAL IRRITATION UPON THE RESPIRATION OF FUNGI. BY ADA WATTERSON.

THE DEHISCENCE OF ANTHERS BY APICAL PORES. BY J. A. HARRIS.

MITOTIC DIVISION OF THE NUCLEI IN THE CYANOPHYCEÆ. BY E. W. OLIVE.

CHEMICAL STIMULATION OF ALGÆ. BY B. E. LIVINGSTON.

THE DIFFERENTIATION OF THE STROBILUS. BY F. E. CLEMENTS.

THE HISTOLOGY OF INSECT GALLS. BY M T. COOK.

MORPHOLOGY OF CARYOPHYLLACEÆ. BY M. T. COOK.

THE PHYLOGENY AND DEVELOPMENT OF THE ARCHEGONIUM OF MNIUM CUSPIDATUM. BY G. M. HOLFERTY.

THE ENZYME-SECRETING CELLS IN THE SEEDLINGS OF ZEA MAIS AND PHŒNIX DACTYLIFERA. BY H. S. REED.

DISCOID PITH IN WOODY PLANTS. BY F. W. FOXWORTHY.

A PLEA FOR THE PRESERVATION OF OUR WILD FLOWERS. BY C. E. BESSEY AND S. M. COULTER.

SECTION H.

ANTHROPOLOGY.

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PAPERS READ.

[The American Anthropological Association met in affiliation with Section H.]

PRESENTATION OF EOLITHS FROM ENGLAND AND BELGIUM. DANISH MUSEUM OF ARCHÆOLOGY. BY GEORGE GRANT MACCURDY.

THE CAHOKIA AND SURROUNDING MOUND GROUPS. BY DAVID I. BUSHNELL, JR.

THE MOUNDS OF THE AMERICAN BOTTOM OF ILLINOIS: REPORT ON A GROUP HERETOFORE NOT MENTIONED AND A NEW LIGHT THROWN UPON THEIR FORMER USE. BY H. KINNER.

THE AFRICAN PYGMIES. BY S. P. VERNER.

THE FUTURE OF THE INDIAN. BY GEORGE A. DORSEY.

THE KNIFE IN HUMAN DEVELOPMENT. BY W J MCGEE.

THE TORTURE INCIDENT OF THE CHEYENNE SUN-DANCE OF 1903. BY GEORGE A. DORSEY.

THE HISTORY OF AN ARICKAREE WAR SHIELD. BY GEORGE A. DORSEY.

PRESENTATION OF CEREMONIAL FLINT AND FACTS RELATIVE TO ITS DISCOVERY. BY H. M. WHELPLEY.

ARCHÆOLOGY OF THE AFTON SULPHUR SPRINGS, INDIAN TERRITORY. BY R. H. HARPER.

THE EFFICIENCY OF BONE AND ANTLER ARROW POINTS AS SHOWN BY FRACTURED HUMAN BONES FROM STATEN ISLAND, NEW YORK. BY GEORGE H. PEPPER.

CERTAIN RARE WEST COAST BASKETS. BY H. NEWELL WARDLE

STONE GRAVES AND CREMATION CISTS IN THE VICINITY OF ST. LOUIS. BY H. KINNER

SOME DRAWINGS FROM THE ESTUFA OF JEMEZ, NEW MEXICO. BY A. B. REAGAN.

A GLOSSARY OF THE MOHEGAN-PEQUOT LANGUAGE. BY J. D PRINCE AND FRANK G. SPECK.

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ALLEN R. FOOTE.

ADDRESS

BY

H. T. NEWCOMB,

VICE-PRESIDENT AND CHAIRMAN OF SECTION I FOR 1903.

SOME RECENT PHASES OF THE LABOR PROBLEM.

OLD PROBLEMS, BUT NEW CONDITIONS.

In the rapid development of modern industry old problems are ever assuming new and perplexing phases, but intrinsically new ones rarely develop. Each age is quick to imagine that its difficulties exceed those which were conquered by its predecessors, and to fancy the latter as free from the obstacles in overcoming which the courage and genius of its own leaders are subjected to their supremest tests. But this is the superficial view only. Just as the principle upon which the most complex mechanism performs its marvelously specialized functions is to be found in the crudest labor-saving devices of the earliest dawn of culture, so the most primitive industrial organization, when subjected to minute scrutiny, is sure to present traces of those elements of friction which, one after another, in different stages of progress, become the particular and absorbing problems of generations to which each in turn seems the sole serious impediment to the realization of perfect conditions.

The labor problem is no exception. It is the struggle between different factors in production over the relative shares of each, and its origin lies deep in fundamental conditions which have existed as long as men have known the

wisdom of saving labor by the use of tools and of conserving productive resources by the device of private property. It will persist, in one or another of its protean forms, until by some unlooked for alchemy man learns to satisfy all human wants without requiring from any individual more labor or abstinence than he will voluntarily undertake. In every historic era this unceasing struggle has left indelible traces upon the record of man's progress, and rarely has it yielded the place of primary importance in the minds of men to anything less compelling than religious zeal.

A PERSISTENT INQUIRY.

How shall the comfort of satisfied economic wants be divided between those who contemporaneously endure the physical discomforts of toil and those who control the other factors in production? This is the everlasting question which, in various forms, has been asked and answered, re-asked and answered again in unending repetition while humanity has struggled from the crudest forms of industrial organization, through slavery and serfdom, up to the wages system. It is asked to-day, when the share of the poorest who labors with his hands is sufficient to purchase comforts which a few centuries ago were beyond the reach of kings, and although the agencies which Capital has established seek daily in the uttermost limits of the earth and among the most distant islands of the sea to bring thence and lay cheaply at the feet of Labor every product that can satisfy or please, the final answer is not yet. Indeed, in this most fortunate land, where sturdy manhood has found nature in her most generous mood and industry and genius have won an abundant and increasing harvest, there is at this hour of highest prosperity a reverberating discontent which seems to some to menace much that has been gained.

The organized demand for a better answer to this persistent questioning than Labor has ever yet received appeals strongly to the sympathies of those who love their fellowmen, and, as long as it is kept within reasonable bounds by a due sense of the responsibilities of strength and the rights of others,

will have the aid and approval of the right-minded. But sympathy may go where sanction must be denied, and in every step of its perpetual struggle for what it rightly or wrongly conceives to be the interests of Labor, and the means of attaining a higher standard of comfort and culture, the demands of organized labor must be subjected to intelligent scrutiny, and the probable consequences of granting them must be calmly and minutely examined.

CONDITIONS OF THE PROBLEM OF DISTRIBUTION.

Let us enumerate a few of the fundamental conditions of this struggle over distribution. Capital is the great labor-saving contrivance and the mother of all labor-saving devices. Withdraw that which exists, and, with the most grinding toil, the earth could not be made to support a tithe of its present population. Stop its further accumulation, and industrial progress would cease until presently it should give place to retrogression. Remove the incentive to abstinence, and saving and accumulation would stop, while the gradual consumption of existing capital, not offset by replacement, would inaugurate a movement toward barbarism. Reduce the incentive, and the pace of progress will be proportionately slackened. But Capital is not only the handmaiden of Labor; it is the accumulated product of labor. Wherever it exists, it is conclusive evidence of previous effort and abstinence. Labor, alone, can pluck the ripened fruit; it cannot increase the product by cultivation, for it cannot subsist during the period of growth. Labor can wade in the stream and catch a few fish with its naked hands, but it cannot spread the net to gather food for a multitude unless Capital provides for its immediate necessities while the fabric is being constructed. Labor can carry an armful of coal or a stick of lumber, but the locomotive which hauls its train of fifty cars, each containing one hundred thousand pounds of coal or lumber, is Capital. But the instruments of husbandry, the net, the locomotive, have no direct or final utility of their own. Of themselves, they neither feed, nor clothe, nor house the body of man, nor minister to his higher needs. They

will not be brought into being, unless, for the effort expended in their creation, their producers are guaranteed a fitting recompense. This recompense must be a share in the products obtained through their agency and the economic name for this share is "interest." Interest, including in that term compensation for the risk assumed, is all that Capital, as such, ever obtains from production; it is the least which it will accept. It is high when the supply of Capital is small in proportion to the demand for it, and low when the condition is reversed. Profit is not for Capital; it is the wages of the usually arduous labor of determining the direction of industrial investments or the differential reward of exceptional economic foresight or technical skill. Those who reap profits are differentiated from those who receive wages by the fact that profits are dependent upon success (possibly it is better to consider that in the case of failure there are really negative profits), while wages constitute a preferred claim, the payment of which is usually arranged for in advance.

THE LIMIT OF WAGES.

Here, then, are the conditions of the problem. Labor must have its wages at all times and under all conditions. In the long run directing efficiency must have its profits and Capital must have its interest. Wages may often absorb portions of the shares of the other claimants, but unless these are eventually satisfied, the efficiency of industry will be impaired and capital will cease to accumulate, either because the owners of wealth prefer to consume it or because they hoard it rather than permit its use as capital on unsatisfactory terms. Thus is the limit of wages fixed. The efforts of organized workingmen to secure higher wages deserve approval so long as they do not threaten industrial efficiency through a reduction of interest or profits below the minimum limits respectively fixed by marginal capitalists and *entrepreneurs*. Demands that exceed these limits would, if granted, produce results which could only react unfavorably upon those who made them. The increase and progressive diffusion of industrial intelligence tend to reduce the amounts

which can be effectively demanded by those whose service to society lies in determining the character and organization of productive efforts, and the rapid accumulation of capital tends to reduce the general rate of interest. Consequently, wage-earners can reasonably anticipate an increasing share of the value annually produced, and if, under favorable conditions, they fail to receive it they may justly demand a change in the proportion which they are accorded.

WHY WORKMEN ORGANIZE.

The instinct which impels workingmen to organize rather than to deal separately with their employers is precisely the same as that which at other points of economic contact has universally led to efforts to mitigate the consequences of competition by the simple device of combination. The single workman, dealing with an employer of many workmen engaged to render similar service, is at exactly the same sort of disadvantage which confronts the small manufacturer who has to sell in a market to which a multitude of competing producers have access on equal terms. There is nothing strange in the fact that the characteristic movement of the great industrial revolution which has been in progress since the invention of the spinning jenny and the power loom has left its impress upon Labor as well as upon Capital. If Labor had not organized, it would have been a sadly belated factor in the industry of the opening years of the Twentieth century. Just as Capital must continue to compete with Capital, so Labor will compete with Labor as long as capitalistic production and the wages system endure, but on either side folly could go no further than to seek the perpetuation of the crude, cut-throat competition which seeks the immediate extermination of the rival at whatever cost to the survivor. Such competition is crude in its methods: it is destructive in its consequences, and it is not, to-day, a means of attaining the highest degree of economic efficiency. Both Capital and Labor are amply justified in uniting to mitigate this kind of competition. It is to be observed, in passing, that the capitalistic combination, when fully justifiable, is the means of

economies in operation and management which lower the cost of production, and in the face of actual or potential competition are always finally expressed in reduced prices. The labor combination has so far almost always lacked this justification, and the leaders must systematically seek it or their organizations must continue to find their entire economic basis in the mitigation of the evils of unrestrained and destructive competition.

THE EMPLOYERS' SIDE.

Enlightened employers do not expect or desire to obtain profits by securing the greatest aggregate of labor, measured in hours or effort, at the lowest cost. The American manufacturer has seen the greatest productive efficiency coincide with the highest wages, and he knows that the countries where workmen receive the lowest real wages are unable to compete in the markets of the world with those whose labor is better paid. He is able to estimate somewhat accurately the superiority of intelligent, well-fed, well-clothed, well-housed and contented workmen over those who do not enjoy similar advantages. He knows that every machine in his factory works better in the hands of those whose standard of living requires an high degree of comfort. Yet in the economic philosophy of American employers there is no place, and there should be none, for gratuities. High wages, liberal wages, are preferred not from any impulse of generosity, which would be out of place and destructive of its own purposes, but because, dollar for dollar, the return from high wages exceeds that from low wages. When this is not the case, it means that the point of over-payment has been reached. The excess of the wages received by the overpaid group, in such an instance, over the normal amount, is a burden which must be borne by the other industries and the other workmen of the same community. Each workman must give in labor a fair equivalent for what he receives in wages, or some other workman will receive less than he gives. The employer who, for the sake of continued peace during a period of high profits or for any other reason, aids in establishing such a condition,

strikes a blow at industrial welfare which in the end will fall most severely upon the wage earners. It is not claimed that the practices of individual employers invariably attain to these standards. Narrow selfishness and unenlightened greed sway their proportions of the members of every industry and every grade in every industry. Employers have dealt grudgingly and even cruelly with workmen in far too many instances and always to their own injury. Yet the conditions which make for fair dealing are so compelling, even if we omit the paramount condition created by the force of public sentiment, and they are so easily read, that it is not too much to say that, in the main, American employers desire to deal fairly, and do deal fairly with the men whose names are upon their pay-rolls.

HOW IT LOOKS TO UNIONISTS.

The economic philosophy of general acceptance among the members of labor organizations is not so easily grasped. Indeed there is reason to believe that, except for a few generalizations of the broadest character, there is no economic creed to which American trade unionists as a class adhere. Among their leaders, there is every shade of belief from the strong individualism of John Mitchell to the socialism of Eugene Debs. Even in the principles to which the various unions of the American Federation of Labor adhere, there is no uniformity, for we find organizations, like the United Mine Workers, which desire a monopoly of all labor engaged in certain kinds of production and move toward it by waging destructive warfare upon existing unions of more modest ambitions, side by side with others which admit only the journeymen workers of single highly specialized trades. Theoretical agreement is probably confined to the propositions that the share of Labor in the products of current industry should steadily increase at the expense of the share of Capital, and that this can be accomplished by the enforcement of collective bargaining. It is less surprising that the first proposition should be pressed by some to the extreme of denying the validity of the claim of Capital to even the smallest share in the benefits following

production than it is gratifying that the socialists, whose philosophical system rests upon this view, have made so little progress in their efforts to turn the labor movement into an organized demand for the socialization of all industry.

DIVERGENT UNION METHODS.

Even in the current practices of unionism there is little uniformity. At their best, as exemplified in the recent history of some of the brotherhoods of railway employees, these practices tend to increase the dignity of Labor and to simplify the relations between employers of large bodies of Labor and the workingmen composing the latter. On the other hand, there have been instances in every great city and in most industries in which organized labor has been made the means of denying to American citizens some of the most fundamental rights of industrial liberty; of intolerable interference with public order, and of oppression, falling with equal injustice upon representatives of Capital and of Labor. What more significant contrast could there be than that offered by American unionism; one day paying tribute at the grave of P. M. Arthur, the conservative leader of a conservative organization, and, on another, parading under the leadership of a creature under conviction for using his position in a labor union as a means of blackmail and the grotesque figure of the man whose infamous name has become a synonym for the unspeakable vileness of the lowest period in the political degradation of the chief city of this country. Yet how short the interval between the funeral of the late Grand Chief of the Brotherhood of Locomotive Engineers and the Labor Day parade led by Parks and Devery.

CONDUCT THE TEST.

I do not bring these facts to your recollection without a purpose. They are submitted as conclusive evidence of the gulf which separates the best organizations from the worst. Between these extremes are undoubtedly to be found representatives of nearly every intermediate degree. In fact,

the same organization will not infrequently appear, within a short period, to be guided by utterly divergent ethical and economic principles. Such a lack of stability is of course unfortunate, but it is attributable to a cause that operates in all voluntary associations, and at times even in the State itself; absence of interest on the part of those whose influence, if exerted at all, would usually fall on the conservative side. The conclusion to be drawn from these facts is an important one. They establish the principle that every labor organization and every demand of a labor organization must be treated, and ought to be treated, according to its independent merit. It is impossible to generalize far beyond the right of workmen to organize, a right which no sane student of industrial affairs and no intelligent employer of labor ever now disputes. Workmen have the right to organize and to do so on such terms and for such lawful purposes as seem good to them, but employers have an equal right to refuse to deal with organizations whose purposes or methods would lead to a loss in efficiency and to reject particular overtures whose acceptance would have that effect. Employers who earnestly desire to accord to a movement, the persistence of which against great opposition and in spite of enormous obstacles of internal origin, establishes the economic soundness of its central principle, will always strain a point in favor of dealing with labor organizations. Indeed no employer ought to decide to refuse to consider an offer to make a collective bargain on the part of his employees except on the most convincing grounds and with the greatest reluctance. To destroy one labor organization is but to prepare the way for another, and the elimination of one set of labor leaders will never be more than the signal for others to enter upon the scene. Nor are the new organizations and the new leaders always to be preferred to the old.

FAIR TREATMENT FOR FAIR EMPLOYERS.

The character of a labor organization is to be measured by its acts and by the principles to which it adheres. The most common tests of character relate to the treatment of non-

union men, restriction of output and the strike. Before any of these, but not detracting from their importance, I should put the attitude of the organization toward the fair employer. What objection can be raised to the declaration that neither a fair workman nor a just organization will enter into an agreement which may compel unfair treatment of a fair employer. Yet this principle, so obviously just, is openly and constantly violated by organized labor. Before the recent Anthracite Coal Strike Commission, witness after witness among those called on behalf of the striking mine employees, testified that prior to the great strike of 1902, he had no grievance against his employer, the Philadelphia and Reading Coal and Iron Company. This great company enjoyed an unimpeachable record for fairness to its employees, and among them there existed no doubt that should unintentional wrong occur it could readily be brought to the attention of its mining superintendent and would be promptly and completely remedied. The man who holds this position, John Vieth, has spent more than half a century in the anthracite mines, beginning as a day laborer. He knows the mines and the miners as probably no other man has ever known or can ever know them: his sympathies are broad; his manner, frank; his honesty, rugged; his fidelity to the industry and every man in it, impartial and unbreakable. The Reading company reduced the price of powder a full decade before its competitors; it established the sliding scale of wages; it never owned a company store; it long ago established an employees' insurance fund, and it pays its miners on the simple per car and per linear yard systems. Yet the organizers, who were sent to the anthracite fields from Illinois in the early part of 1900, were able to induce the employees of the Reading to pledge themselves to an agreement binding them to desert their fair and generous employers whenever the miners in the Northern and Western anthracite regions should feel sufficiently dissatisfied with the wages or conditions in their fields to demand a general strike. This is precisely what happened in May, 1902. The satisfied employees of the Schuylkill region had no desire to strike, but because the men

of the other regions desired to do so, they consented to attack the prosperity of the company which had brought prosperity to them, and, with no grievance of their own, to strike a severe blow against American industrial stability. This action is typical of hundreds of instances in which the most generous fairness on the part of individual employers has failed to protect them against sharing the penalty of real or fancied unfairness on the part of the owners of other establishments with which they had no connection. In fact, with few exceptions, it is the current practice of American unionism to refuse any special protection to the employer who distinguishes himself from his competitors by the liberal treatment of his employees while, in a spectacular manner and with unbending spirit, visiting the sins of those who displease them alike upon the just and the unjust. Such a practice is destructive of the legitimate ends to be gained by organization. It places the generous employer at a greater disadvantage than that resulting from the ordinary competition of his rivals, and utterly destroys the business advantage that ought to go with righteous methods.

The principle which requires the fair treatment of fair employers must be established as a part of the creed of unionism before the latter can become a genuine means of industrial and social betterment. This would require the revision of some very prominent features of the methods now current among labor organizations; it would abolish the sympathetic strike and also the general strike which, in recent instances that all will recall, has frequently paralyzed the industry of entire sections. It would leave labor controversies to be settled by the parties directly concerned and would pretty effectually deprive both of the equally fickle support and opposition of public sentiment based on mere personal inconvenience and annoyance.

TREATMENT OF NON-UNION MEN.

The attitude of many numerically strong labor organizations toward those workmen who refuse to join their ranks approaches closely to a denial of personal freedom in matters

concerning which no liberty-loving individual can submit to dictation. No organization except Government can, with the sanction of the intelligent and far-seeing, be permitted to demand allegiance. Yet many labor leaders declare that no workman has a moral right to remain aloof from their organizations, and compare those who dare to do so with those guilty of treason in its most repulsive forms. This doctrine has its natural consequence, during the stress of great strikes, in violence directed at the persons and property of those who give practical expression to their independence by retaining employment against the wishes of their fellows or by accepting positions abandoned by those on strike. It would be absurd to expect any other result. Idle men of somewhat limited culture, of violent passions and possessing a strong sense of the solidarity of their class, with abundant opportunities for the development of mob spirit, will always attempt to compel obedience to what they regard as the moral law when convinced that those who violate it are doing so to the positive injury of their class. Hence, when John Mitchell and other leaders in the great strike of 1902 proclaimed against violence, in the abstract, with one breath, and with the next compared the men who were at work to Benedict Arnold and to the tories of the Revolutionary period, they laid a foundation upon which it is not strange that other men, whose opportunities to acquire self-control had been more limited than their own, should erect a superstructure of violent interference with the rights of others.

These leaders did not even verbally condemn the use of the boycott for the purpose of enforcing the new commandment: "Without permission of the majority thou shalt not work." It was invoked to drive the daughters and sisters of non-union men from employment as teachers in the public schools and in factories, to prevent medical attendance upon the sick and to interfere with the interment of the dead. Its most common use was to deprive families of the necessaries of life and fathers who sought work for the sake of their little ones were sometimes compelled to see them suffer from hunger because no one dared to sell them food. From this

expedient to dynamite how short the step. No one need be surprised that it was repeatedly taken.

THE VOICE OF AUTHORITY.

It stills remains to be seen whether those who have been most prominent in inculcating this new doctrine of the depravity of refusing to join an organization and especially of insisting on the right to work on terms which are unsatisfactory to others will learn wisdom from the Anthracite Coal Strike Commission and the President of the United States. To appreciate the contrast between their teachings and those of the great, extra-legal labor commission and the President who created it, it is necessary to compare certain expressions of Mr. Gompers and Mr. Mitchell with the later official utterances of the Commission and the President. Mr. Gompers is the author of the following:

". . . the individual workman who attempts to make a bargain with the directors, or the representatives of such a directorate, simply places himself in the position of a helpless, rudderless craft on a tempestuous ocean. If he did but himself a wrong we might pity him and concede not only his legal but his moral right. But the workman who toils for wages and expects to end his days in the wage-earning class, as conditions seem to point, it will be a necessity, his bounden duty to himself, to his family, to his fellowmen and to those who are to come after him to join in the union."

Mr. Mitchell's expression is, perhaps, still more forcible. He said of the non-union man who works during a strike that:

"He is looked upon, and I think justly, in the same light that Benedict Arnold was looked upon, or any traitor. He is a man that fails to stand for the movement that the people stand for, and, after all, the majority of the workers in any particular community reflect the public sentiment of that community. It is the movement of the people of that com-

munity, and if a man wants to desert his fellow workers and wants to prevent them from accomplishing good ends, then he is justly looked upon with disfavor by those who are right, because his working does not affect himself alone. If it only affected himself, it would be a different proposition, but the fact that he works helps to defeat the objects of the men who go on strike."

And then, answering the inquiry whether the "lives of the wives and children" of the men he had thus condemned ought "to be made unendurable," Mr. Mitchell declared:

"I think those wives and children had better ask their fathers."

Both of the foregoing declarations constituted part of the record before the Anthracite Coal Strike Commission when it unanimously adopted a report containing the following:

"The non-union man assumes the whole responsibility which results from his being such, but his right and privilege of being a non-union man are sanctioned in law and morals. The rights and privileges of non-union men are as sacred to them as the rights and privileges of unionists. The contention that a majority of the employees in an industry, by voluntarily associating themselves in a union, acquire authority over those who do not so associate themselves is untenable. . . . It should be remembered that the trade union . . . is subordinate to the laws of the land and cannot make rules or regulations in contradiction thereof. Yet it at times seeks to set itself up as a separate and distinct governing agency, to control those who have refused to join its ranks and to consent to its government, and to deny to them the personal liberties which are guaranteed to every citizen by the Constitution and laws of the land."

Finally, exercising the authority voluntarily accorded to it under the terms of the submission, the Commission established the wise and salutary rule:

"That no person shall be refused employment, or in any way discriminated against, on account of membership or non-membership in any labor organization; and that there shall be no discrimination against or interference with any employee who is not a member of any labor organization by members of such organizations."

It is very highly to the credit of organized labor that among the seven members of the tribunal which, without a dissenting voice, enunciated this fundamental principle of fairness toward all labor sat the distinguished chief of the Brotherhood of Railway Conductors, probably the ablest of the living labor leaders of America, Edgar E. Clark. The last paragraph quoted has received especial Presidential approval, having been quoted in full in President Roosevelt's letter of July 13 last to the Secretary of Commerce and Labor, in which it is followed by these words:

"I heartily approved of this award and judgment of the Commission appointed by me, which itself included a member of a labor union. This Commission was dealing with labor organizations working for private employers. It is, of course, mere elementary decency to require that all the Government departments shall be handled in accordance with the principle thus clearly and fearlessly enunciated."

Thus in decreeing that every productive establishment of the Federal Government should be an "open shop," in which there should be no discrimination among American citizens on account of race or creed or membership or non-membership in any legitimate organization, the President in the plainest terms gave the weight of his endorsement to the sound doctrine that the discrimination thus forbidden in the workshops of the Government ought not, anywhere, to be permitted. The freedom of American workmen could not survive the general abandonment of the "open shop." It is infringed whenever there is any discrimination such as can no longer exist in the Government shops. Workmen who have faith in their own

abilities, who treasure the liberties won for them by their predecessors here, who realize the spirit and the beauty of the Golden Rule, will not seek to debar others from the right to work on account of a disagreement as to the propriety of the terms and conditions on which work can be obtained. The "union label" is one of the milder measures for compelling men to join organizations against whose principles or practices they wish to protest by remaining aloof from them. He who refuses to purchase goods not having this label is attacking the independence of some fellow-citizen. The employer who weakly assents to its use becomes a participant in a conspiracy against those workmen who dissent from the principles or methods of those who control the organizations in their fields. It is not pleasant to condemn a device which does afford some guarantee that the goods to which it is attached are not produced under oppressive conditions, but while giving partial protection against this danger the "union label" threatens one of the most fundamental and sacred rights of every individual. Divest it of its proscription of the non-union man and its power for good will win for it deserved welcome from all right-thinking men.

RESTRICTION OF OUTPUT.

There would be little utility in discussing the restriction of individual output in its theoretical aspects. That the practice is unsound in economics is recognized by all students and even by those leaders of labor organizations who are unable to deny that it is followed, more or less extensively, by the members of their organizations. This general condemnation of the practice makes it extremely difficult to determine its extent, but no one doubts that in one way or another it is a characteristic of most unions. It cannot, however, be said to have originated with them. Whenever two men work side by side, for an employer, there is a decided tendency to limit the labor of both by the capacity of the less skillful and energetic. As the number of workmen increase the tendency in this direction is inevitably strengthened, and while there may be some increase, through example and emulation, in the labor

of those who would do the least if working alone, the net result is always expressed in an average that is much nearer the capacity of the least capable than that of the most efficient. All this will happen in any establishment without the aid of a labor union. What, then, is the consequence, in this connection, of organization? Usually its first effect is that the restriction which was formerly tacit and somewhat irregularly enforced is reduced to a set of definite regulations that are systematically enforced. It may not become greater in amount, although it is not unlikely that it will. There is some evidence, however, that the improved economic perception on the part of labor leaders is causing the older organizations to abandon their efforts in this direction. Yet the recent growth of the unions in numbers and power, and the reluctance of employers to resist their aggression in this particular, during a period of such tremendous general prosperity that nearly every productive establishment was taxed to its utmost capacity, have undoubtedly led to an extension of the practice of restriction which must be checked. The unit of production per employee per hour has suffered a very considerable decrease in almost all American industries during the last six or seven years, and this diminution of effectiveness has placed a more severe burden upon industry than the enhanced wages by which it has been accompanied. The record of the United Mine Workers in the Anthracite region is probably an extreme one, but it can be more advantageously studied than any other on account of the elaborate investigation prosecuted last year. The testimony taken by the Strike Commission contained instances of probably every conceivable method by which the output of a body of workmen can be kept down to the level fixed by the least able and industrious. Those who dared to rebel against rules restricting their earnings were subjected to the ill-will and the systematic oppression of their less intelligent and energetic comrades, until they either became less efficient or were driven from the mines. It is necessary to be patient with folly that springs from ignorance, but there is little excuse for leaders who, knowing the truth, do not use all their tre-

mendous influence to spread an intelligent understanding of the simple economic principles which would at once destroy this most vicious of self-limiting practices.

STRIKES.

That recourse to the strike should ever be necessary is wholly deplorable, but the condition of men whom the laws deprived of the use of this industrial weapon of last resort would be indeed pitiable. Freemen must have the right to work and the right not to work, and they may not be impelled to choose the former by any command more imperative than that springing from their own desire to enjoy the fruits of exertion. The whole fabric of industry and commerce rests on bargains toward which there is no compulsion stronger than this. Between the buyer and seller of commodities there are successive offers and counter-offers until a point acceptable to both, but less satisfactory to either than his original demand, has become the point of contract. The corporation and the "trust" do away with a great deal of dickering between individuals, and in a precisely similar way the labor organization attempts to substitute a single collective bargain for a multitude of individual bargains. If, however, the corporation and the trust are unreasonable in their demands, every one now knows that the potential competition of smaller concerns, which always exists, is speedily actualized and the productive organizations, that have shown their commercial incompetence to bargain reasonably with buyers, are destroyed. So it should be with labor organizations. Those organizations which are reasonable in their demands will usually establish their right to survive by remaining at peace with the employers; those whose frequent strikes and repeated complaints of the alleged tyranny of employers prove their inability to bargain are usually inefficient in their efforts to promote the interests of their members and ought to pass out of existence. Yet the decision as to the terms which they will accept must always be left with the workmen, organized or unorganized. The right to strike ought to be used rarely and reluctantly; its use should always throw the burden of

justifying its course at the bar of public sentiment jointly upon the employed and the employer; it can never be necessary except by reason of the grievous fault of one party or the other; yet it may be necessary and the greatest protection against its becoming so, save that which lies in the development and spread of a broad and intelligent spirit of humanity, lies in its exceedingly careful preservation. Generally speaking, however, the union which strikes on small provocation and frequently is to be classed among those which are undesirable, and the credit of any labor organization ought to be in inverse proportion to the frequency of its resort to this extreme method of enforcing its demands.

As somewhat justifying the assumption that every strike is evidence of lack of capacity somewhere, and perhaps indicating where the blame more frequently resides, I would call your attention to the very large number of strikes which always attend the transition from a period of great industrial prosperity to one of relative depression. The interpretation of this phenomenon is very simple. From almost the beginning of a period of prosperity the leaders of organized workmen perceive that their position is one of growing strength. The demand for products is a demand for labor, and as the one is expressed in rising prices the other is naturally translated into rising wages. Organizations formulate their demands, make them, and they are granted. New demands and new concessions follow in an alternation which becomes more rapid as prosperity appears more intense, the willingness of employers to grant even seemingly extravagant demands as to wages or conditions being based on a confidence in the continuance of heavy demand and high prices which often amounts almost to intoxication. While this process has been going on the effect of high wages and reduced efficiency is being transferred to the consumers, always with some addition to make up for the exactions of those in charge of production. Naturally, this cannot continue forever. Sooner or later there is a consumers' "strike." That is, high prices ultimately reduce the effective demand, orders come less freely, the bubble is about to burst. Employers rather

promptly perceive the situation more or less clearly; labor too frequently does not. More wages or less work, or both, are again demanded, and, as this time the employers see that the cost of acquiescence cannot be shifted or realize that a curtailment of production must soon occur, the demands are refused. The strike which, if the workmen are ill-advised, follows, marks the turning point from prosperity to depression.

The other typical strike is a protest against a reduction in wages when the decline in commercial activity is in progress, or before the change to perceptibly better conditions has arrived. Such strikes are less frequent but much more likely to be creditable to the judgment of the strikers. Employers rarely refuse reasonable demands while industry is prosperous and the labor market empty or nearly so; some of them do attempt oppressive reductions in wages or unjust modifications in conditions when the times are dull and the labor market glutted with the unemployed. This is not to say that radical reductions in wages may not be necessary; they are very apt to be after such a period of unprecedented activity in every line of industry as that which is but just closed or closing, but it should be recognized that when due allowance for the changed conditions has been made everywhere there may be some employers who will endeavor to take advantage of the situation and to deal unjustly with their workmen. May the number of such employers be few and the resistance of their employees wise, fearless and effective.

OTHER TESTS.

The character of any labor organization is further to be tested by its principles and practices in reference to labor-saving machinery, profit sharing, pensions, insurance funds, home ownership by its members, admission of applicants for membership, apprentices, the boycott, the manner in which it conducts itself toward other unions, and its rules and general policy. The verdict of intelligence concerning most of these matters is so clear that discussion would hardly be warranted. A wise policy will prevent any labor union from

discouraging the introduction of improved machinery, from refusing to accept or opposing fairly formulated efforts of employers to obtain greater loyalty from employees, from counselling against the ownership of homes, from upholding the boycott, from preventing the industrial education of intelligent youth, and from permitting controversies with other unions to interrupt work or occasion inconvenience to blameless employers. That particular organizations have grievously erred in these matters is perhaps much better known than that some have stood steadfastly for sound principles.

These defects in the current beliefs and practices of some prominent labor organizations have been pointed out in no spirit of intolerance. The evils are widespread and serious; they must be plainly pointed out and bravely overcome; but they are not necessary accompaniments of such organizations. In fact, as to most of them the history of several highly successful unions can be cited to show that among organizations composed of the most intelligent workmen they are likely to be eliminated. It is even more true that the much less pardonable practices which involve blackmailing employers and combinations with unscrupulous representatives of Capital to rob consumers and destroy competitors are merely temporary consequences of an early recognition of strength which is not restrained by a sobering consciousness of responsibility or by ability to perceive the consequences of such injustice.

VALUE IN ORGANIZATION.

The conclusion is that while the labor problem must always persist, the organization of labor will continue and will increase its power to be of service, not only to workmen but also to society. The principle of organization will not only survive the defeat and destruction of those organizations which obstinately adhere to vicious principles and practices, but the genuine progress of the labor movement will be substantially advanced every time such deserved defeat is administered.

ARBITRATION.

While this progress is being made toward the attainment of better things and substantial results are awaited, the public properly searches for a means of preventing or mitigating the annoyances and losses that spring from the interruption of production caused by labor conflicts. Until employers and employees learn such sweet reasonableness in bargaining together as to avoid strikes how shall their number and their evil consequences be reduced? Obviously the demand is for a temporary remedy for a difficulty which ought ultimately to disappear. With this fact kept carefully in view it is safe to consider the remedy of arbitration. This has actually but one form. To be arbitration at all it must be wholly voluntary. The term compulsory arbitration is self-contradictory, and however it may be disguised it really means the creation of a new type of court endowed with authority to make contracts relating to labor services. Arbitration—voluntary arbitration—is a term so grateful to the ear to which it comes as a substitute for the clash of bitter industrial struggles that it seems ungracious not to commend it without qualification. If men cannot agree what can be better than to submit their differences to the settlement of a disinterested and impartial third party? *If men cannot agree.* This qualification begs the entire question. Reasonable men can agree and unreasonable men must become reasonable or be replaced, in industrial affairs, by those who are. One way in which unreasonable men arrange for their own replacement is by getting themselves into situations out of which they cannot be extricated except through the assistance of others. The adjustments of industry are too delicate to endure, without injury to all concerned, the frequent interference of the disinterested. A strong personal interest is the element which is most effective in preventing irreparable mistakes. Arbitration may be the smaller of two evils, but no one should fail to recognize it as an evil. Aside from the fact that it leaves the determination of matters of primary industrial importance to persons who will neither gain nor lose by the

success or failure of the industry, it is evil in its consequences, because, when there is reason to rely upon its being arranged for, that fact constitutes an incentive to making, and insisting upon, unreasonable demands. The easy-going policy which consents to the submission of questions vitally concerning the welfare of an enterprise to persons who have no stake in its success naturally leads to the easy-going method on the part of arbitrators which is expressed by "splitting the difference" between the conflicting demands of both of the contending parties. This is the almost uniform result of arbitration. If you will turn to the decision and award of the recent Anthracite Coal Strike Commission you will find that that ablest and most impartial of arbitration boards was not able to avoid this nearly inevitable result. In its pages you will read the contradiction of every substantial averment of the striking mine workers. You will find that the wages of the employees of the anthracite operators did not, in April, 1902, compare unfavorably with those of bituminous miners or men in other employments of similar character. You will find that the conditions of life and the standard of living in the anthracite counties of Pennsylvania was not lower than in comparable regions. You will find that the basis of payment was not unfair to the workmen. You will find the United Mine Workers described as a body too strongly influenced by bituminous coal interests to be a safe factor in the anthracite industry. You will find that boys voted in its meetings and gave a reckless tone to its management. You will find that the period of the great strike was one of lawlessness and violence, which the leaders of the organization could not or, at any rate, did not, effectively check. So much the gentlemen of the Commission gathered from unimpeached and unimpeachable testimony, and so much they clearly, concisely and fearlessly set down in the permanent record of their arduous and graciously accepted task. But after bravely announcing these facts in terms quite equivalent to declaring that the strike had no justification, the Commission yielded, as any other arbitrators would have yielded and as nearly all arbitrators will yield in future con-

troversies, to the impulse, commendable in itself, to deal generously with those who have relatively little and awarded a general advance in wages.

"COMPULSORY ARBITRATION."

The term compulsory arbitration in the literal sense of the words is a verbal absurdity, but it refers to a definite idea and one fairly understood by all. Those who favor it urge that when men will not reasonably agree on a contract relating to wages or other conditions of employment, and will not agree to let some third party make a contract for them, they ought to be compelled to adopt the latter course. The adherents of this view are very apt to begin their argument with the assertion that "there are three parties to every strike"—the strikers, the employer and the public. They quite understate the number; there are five. There is, of course, always the public or rather the consuming public. Then on the side of labor there are always those, mistaken and misguided, perhaps, but American freemen after all, and entitled to that liberty under the law which has been described as "freedom to do as you please and take the consequences," who are willing to work on the terms rejected by the strikers; as well as those who have declined to work. On the side of capital, there may be supposed always to exist some one, over sanguine, perhaps, but entitled to experiment as he would with his own, who would employ the strikers on their own terms; as well as the former employer. Compulsory arbitration shuts its eyes to both those willing to work for the rejected terms and those willing to become employers on the terms demanded. It sees only the old employers and the old employees, and would force them to continue the industry on terms very likely to be unsatisfactory to both. Manifestly, when this court of so-called arbitration has issued its decree containing the terms of a new labor contract, it must have some effective means for its enforcement. But by what process, consistent with freedom, is an employer to be compelled to pay wages that he believes must lead to bankruptcy, or

employees to work on terms which they regard as so unjust that they prefer idleness to their acceptance? Such power is beyond the limits of governmental authority as they are established in the conditions essential to the preservation of human liberty. Men must be free to contract or not to contract, to work or to refuse to work, to remain in an employment or to leave it, to utilize their wealth as capital or to withhold it from the fields of production, to open their workshops or to close them, and there can be no limitation upon their rights in these particulars except as fixed by their own voluntary contracts, which does not dangerously reduce the liberties of the citizen. Public opinion may praise or condemn the manner in which you or I exercise our legal rights and privileges, and in the face of it we may be driven to act otherwise than as we would. This pressure is legitimate, and when the public is not led astray by prejudice or wrongly instructed by demagogues the compulsion of its intelligent opinion often has salutary results. There can be no objection to this sort of compulsion, and if it leads to the arbitration of individual disputes, which would otherwise have caused prolonged and bitter strikes, it probably leads to the choice of the least evil of the available ways of escape from a condition too evil in itself not to result in some more or less permanent inconvenience. The difference between the compelling pressure of public opinion and the exercise of governmental authority is wide. If such authority is used by officers of a government to which power to compel arbitration has not been delegated, then that government has undertaken to over-ride its own laws, and regard for the law by the officers of government constitutes the whole difference between a despotic government and one which rests on the will of a free people. The humblest American citizen and the wealthiest American corporation are alike entitled to exercise every right which they possess under the laws which the people have made, and when any particle of the power or the prestige attaching to official position is used to curtail the liberty of either that of both is endangered. Public opinion may condemn a particular act which is not in violation of any law and, if

unanimous and strong, it will usually be obeyed; but the hand of government must never be lifted to hasten the compliance. So long as the act is legal, government and the officers of government have no business with it. If the popular respect attaching to the most exalted office in the land has lately been made a means of compelling men to submit to arbitration the manner in which they shall exercise the rights which no one denies are theirs, there has been a misuse of official position and a precedent has been established which, if followed, will sooner or later seriously impair the quality of American liberty. Compulsory arbitration has been rejected by organized labor, and when Americans generally comprehend what is meant by that term they will have none of it whether through statutory enactment or by the unauthorized action of even the highest officer of their government.

THE OUTLOOK.

But if voluntary arbitration is no more than a temporary and rather dangerous makeshift, and compulsory arbitration is utterly to be condemned, what can be done? The answer has been given—men must learn to bargain together reasonably. The remedy ought to appeal to us more because it is a process and not a panacea for all the ills of industrial conflict. That men can learn to settle their disputes over wages without outside aid, and that unions can make and keep collective bargains, has been abundantly proven during the recent industrial experience of the United States. All that is required is that there shall be more of this reasonableness and much less of its opposite. That this will come with the growth and spread of intelligence there need be no doubt. When workingmen and employers scrutinize more thoroughly the conditions by which their relations are fixed they will appreciate the wastefulness of friction and will know that reasonable dealing and the observance of the Golden Rule constitute the best of all policies. In attaining this state of higher intelligence organizations of employees and of employers will bear an important and useful part. Whatever

evils may be discovered in the current practices of either class of organizations, however absurd the doctrines or crude the practices of some of them, no matter even how ill-advised their leadership, the contact of man with man which they directly cause, must, in the long run, lead to higher principles and better methods. Satisfaction with the distribution of the results of productive effort as between wage earners and capitalists, we will not see. Probably, if we did see it, we would wish for a condition which gave more occasion for effort and more justification for hope. But while complete satisfaction with the proportions received is neither likely to be attained nor properly to be considered as entirely desirable, the time when much of the present friction shall have disappeared is already very clearly foreshadowed.

PAPERS READ.

[The first five papers were read before the Society for the Promotion of Agricultural Science and Section I in affiliation.]

FUNCTIONS OF FORESTRY IN THE NEW AGRICULTURE. BY THOS. H. SHERRARD.

IMPROVEMENT IN FARM MANAGEMENT. BY W. M. HAYS.

ECONOMIC FUNCTIONS OF LIVE STOCK. BY CHARLES F. CURTIS.

AGRICULTURAL ECONOMICS. BY H. C. TAYLOR.

EVOLUTION OF AGRICULTURE IN THE MIDDLE WEST AND ITS SOCIAL AND ECONOMIC SIGNIFICANCE. BY EUGENE DAVENPORT.

RELATION OF THE FAMILY TO THE LABOR PROBLEM. BY JOHN W. DAY.

MUTUAL INSURANCE FOR PREVENTION OF STRIKES. BY EDWARD ATKINSON.

WHEN LABOR IS KING. BY MISS ALISAN WILSON.

STATUS OF SOCIAL AND ECONOMIC SCIENCE IN HIGH SCHOOLS. BY W. J. S. BRYAN.

STATUS OF INSTRUCTION IN SOCIAL AND ECONOMIC SCIENCE IN NORMAL SCHOOLS. BY HENRY W. THURSTON.

WORK OF THE COLLEGE IN THE FORMATION OF SOCIAL AND ECONOMIC OPINION. BY ROBERT J. SPRAGUE.

STATUS OF INSTRUCTION IN SOCIAL AND ECONOMIC SCIENCE IN UNIVERSITIES. BY J. H. HAGERTY.

PUBLIC PURPOSES FOR WHICH TAXATION IS JUSTIFIABLE. BY FREDERICK N. JUDSON.

SERVICES OF COMMERCIAL ORGANIZATIONS IN THE SOCIAL AND ECONOMIC DEVELOPMENT OF CITIES. BY WM. F. SAUNDERS.

SOME RECENT DEVELOPMENTS IN REPRESENTATIVE GOVERNMENT. BY GEO. H. SHIBLEY.

WALL STREET AND THE COUNTRY. BY CHARLES A. CONANT.

SOCIAL AND ECONOMIC SIGNIFICANCE OF STREET RAILWAY TRAFFIC IN CITIES. BY E. DANA DURAND.

SECTION K.

Physiology and Experimental Medicine.

OFFICERS OF SECTION K.

Vice-President and Chairman of the Section.

H. P. Bowditch, Cambridge, Mass.

Secretary.

Frederic S. Lee, New York, N. Y.

Member of Council.

R. H. Chittenden.

Sectional Committee.

William H. Welch, Vice-President, 1903; Frederic S. Lee, Secretary, 1903; H. P. Bowditch, Vice-President, 1904; Frederic S. Lee, Secretary, 1904.

J. McK. Cattell, 1 year; R. H. Chittenden, 2 years; W. T. Sedgwick, 3 years; Frank Baker, 4 years; C. S. Minot, 5 years.

Member of General Committee.

G. R. Sternberg.

PAPERS READ.

[No papers were read before Section K at the St. Louis meeting.]

EXECUTIVE PROCEEDINGS.

EXECUTIVE PROCEEDINGS.

Report of the General Secretary.

The fifty-third annual meeting of the American Association for the Advancement of Science was held in St. Louis, December 26, 1903, to January 1, 1904. This was the second time the Association had met in St. Louis, the first being the twenty-seventh meeting in 1878. The Association has met west of the Mississippi but six times.

The number of members in attendance was 385, while the number in the affiliated societies was 81, making a total attendance of 466. This places the meeting fifth in point of numbers of those held during the last ten years. As the total membership has rapidly increased in this time, this would seem to be a small meeting, but there are various reasons to account for it. The first and strongest of them is that the Exposition will be held in St. Louis next summer and a large number of the members expect to visit the city at that time. Hence they did not feel like going to St. Louis in the winter, notwithstanding their strong desire to attend the meeting of the Association.

Although the meeting was small in point of numbers, it was large in point of papers and earnest work in the section room. Many of the sections were very largey attended and had so many papers that they could not complete them during the regular time assigned. Several evening meetings were held, and at least two of the sections held meetings after the final adjournment of the Association. This shows that the meeting was what might be called a working meeting. Those who had papers to present were there and took active part in the proceedings. It was unfortunate that a larger number could not have been present, but any meeting at which a large number of papers is presented, and where a strong and vital interest is taken in the work of the section room, must be called a successful one.

Perhaps the second reason why the attendance was small was in the fact that the policy of the Association, which calls for working meetings, does not meet hearty support from all of the mem-

bers. There is still some discussion going on as to whether it would be better to have a summer meeting or a winter meeting, or perhaps both. Some of the older members do not feel like traveling long distances during the winter and subjecting themselves to the changes of temperature and other discomforts which come from winter travel. In some cases it is not possible for college professors to get away from their institutions during the week of the meeting, and still others do not like to leave their families during the holiday vacation. On the other hand, the majority of those present seem to feel that it is best to continue the present method, for a time at least. There was no open opposition to the winter sessions, but when the vote was taken in the General Committee the winter meeting for next year was unanimously decided upon.

Winter meetings do not readily lend themselves to excursions. The time must be taken up in the reading and discussion of papers, and the social element must come in the form of banquets and smokers. St. Louis did all in its power to entertain the convention, and several excursions were arranged, notwithstanding the unfavorable season.

Affiliated Societies.

The following affiliated societies held meetings in conjunction with the Association:

The American Anthropological Association.
The American Chemical Society.
The American Mathematical Society. (Chicago Section.)
The American Microscopical Society.
The American Physical Society.
The American Psychological Association.
The American Society of Naturalists.
The American Society of Zoologists. (Central Branch.)
The Association of Economic Entomologists.
The Association of Plant and Animal Breeders.
The Astronomical and Astrophysical Society of America.
The Botanical Club of the Association.
The Botanical Society of America.
The Central Botanists' Association.
The Entomological Club of the Association.
The Fern Chapter.
The Geological Society of America.
The Sigma Xi Honorary Scientific Society.
The Society for Horticultural Science.
The Society for the Promotion of Agricultural Science.
The Wild Flower Preservation Society of America.

The policy of encouraging the affiliation of scientific societies with this Association has been continued, and two more societies, the Society of College Teachers of Education, and the Society for Horticultural Science, have been added to the list. Some of the strongest of the affiliated societies have not sought any connection with this Association. It would seem that an earnest effort should be made to bring about some connection between these organizations and our own. "In union there is strength." The scientific forces of the country should stand together, and whenever it comes that assistance is needed for scientific research. or favorable legislation is needed for any purpose, it will be obtained much more readily if it is known that practically all the scientists of the country are back of the Association which asks for such action.

The first session of the fifty-third meeting of the American Association for the Advancement of Science was called to order in the auditorium of the Central High School, St. Louis, Missouri, at 10 A. M., Monday, December 28, 1903, by the retiring President, Dr. Ira Remsen.

DR. REMSEN: Ladies and Gentlemen: My duty this morning is a very simple and a very pleasant one. Having served my allotted time, one year, it devolves upon me to introduce to you my successor in office. I need only mention his name—he is already known to you. Perhaps even that is superfluous. As you know, at the Washington meeting the Association elected as President for this year one who represents economic science, and that was a point that was emphasized. I believe it is the first time that a representative of that line of work has been chosen to the presidency. That is no reflection upon the kind of work which is done by those who are connected with the economic section. It simply indicates that the Association has been somewhat belated in recognizing the value of that work. But the election of Colonel Wright has a recognition at the same time of his personal qualities, his personal distinction, and the value of his own personal labor. You know he is the United States Commissioner of Labor, and has been prominently before the country for many years, especially during the last year, when his work has brought him in contact with problems that touched all of us in our homes. He is not only Commissioner of Labor for the United States, but is a profound and thorough student of economic problems, and he has further taken upon himself the duties of the head of an educational institution, and I introduce him as Commissioner of Labor and President of Clark College, of Worcester, Massachusetts. I have the pleasure of introducing to you my successor, the Honorable Carroll D. Wright.

MR. WRIGHT: Ladies and Gentlemen: I will not detain you at this moment, because later on I shall have an opportunity to ex-

press myself, and will proceed at once with the business of the morning. We have with us several gentlemen who have kindly consented to meet with us, and it is for them to give a welcome to Missouri and St. Louis. First I will present to you the Honorable David R. Francis, who is president of the local committee this year.

Mr. FRANCIS: Mr. President, Ladies and Gentlemen: I don't know why I was selected as the honorary president of the local committee—certainly not for any scientific attainments I may have, and I regret to say that it cannot be for the reason that I have contributed materially toward the advancement of science in any way. However, I accepted the honor which the local committee chose to put upon me, and if this is the only duty I have to perform, it is certainly a pleasant one, because I take very great pleasure in saying on behalf of the local committee that we extend a very cordial welcome to the visiting members of the Association for the Advancement of Science. Any city should feel honored by being made the scene of your meetings. We realize that St. Louis at this time has the eyes of the world fixed upon her to a very great extent. We know that the responsibility in connection with the prominence that has been given to this city and to the enterprise it has undertaken is very great. We are glad, therefore, ot all opportunities that present themselves to show the people whose judgment we value as highly as we do that of the members of this Association what we are doing toward celebrating in St. Louis a great event in the history of the country. That exposition, which will be universal in character, which is to commemorate, as you are aware, the one hundredth anniversary of the purchase of the Louisiana Territory, will not be confined to an exhibit of the material products of the world. The management of the exposition has not lost sight of how much civilization, society, and all progress is indebted to science. We trust that this exposition will be a marker in the progress of science from its earliest beginnings. The comprehensive and ambitious scale upon which this international congress of arts and science has been planned, if carried out, as we trust it will be, will serve as a marker in the progress of science from its very earliest beginnings.

It is not proper at this time for me to dilate upon the benefits of the exposition which will be opened in this city in May of next year, but I am sure you will pardon me if, on behalf of that enterprise as well as the chairman of the local committee,. I extend to you a welcome to St. Louis. All of St. Louis is now so thoroughly intertwined, as it were, with this exposition, that we cannot dissociate any meeting held in the city from the exposition if we should desire to do so. On behalf of that exposition, I desire to extend an invitation to you to visit the grounds during your stay in St. Louis, and to tender to you the hospitality of the exposition.

If the weather is propitious, as it promises to be, we shall give you an opportunity to see what has been done in a physical way. Inasmuch as there is a prospect of your having such an opportunity, I shall not endeavor by words to give you a description of something which in our judgment is beyond description.

The moral benefits of an exposition could be better appreciated and expressed by this audience than I can describe it. It has struck me, however, in the last ten days or two weeks, when reading, as we all have, of the imminence of foreign wars, that if by any negotiations, by any means, the opening of hostilities could possibly be postponed for five months, there would be no hostilities. Those nations which have accepted the invitation to participate in this exposition would be assembled here, as they will be on the first day of May if no foreign war intervenes to prevent, their acquaintance would enhance their mutual respect, and an intelligent comprehension of their mutual interests would remove all necessity for and all possibility of war. Every international exposition such as we propose to hold here in 1904 is a peace congress. There is great occasion for a universal peace congress to be held just at this juncture in the world's history. If, therefore, I say, the opening of these hostilities could be postponed for five months, the peaceful effect of a universal exposition would have a demonstration that would be long remembered and whose effects would never be forgotten.

But I am digressing from my duty as chairman of the local committee, which is to say to the members of this Association how much we feel honored by your meeting in St. Louis—how we desire to have you feel that you are welcome here. I am sure that I but express the sentiments not only of the committee, but of the entire people of St. Louis, when I say to you that if we do not voluntarily do what we should to make you feel comfortable and at home, we desire suggestions, for any dereliction on our part to extend to you a whole-souled western hospitality is not through any want of desire but through failure to know what your wishes are. On behalf of the local committee, Mr. Chairman and members of the Association, I desire to extend to you a formal and a hearty western welcome.

President WRIGHT: It is a pleasure to present to the Association the Honorable C. P. Walbridge, ex-Mayor of the city of St. Louis—his Honor, ex-Mayor Walbridge.

Mr. WALBRIDGE: When Professor Trelease invited me to come here and make a short welcome address I began to rummage the attic of my mind for suitable material, and I found the conditions very unsatisfactory. I found first, up in the attic, a lot of magazine and newspaper articles describing all sorts of new things—new stars, new elements, new metals, new machines, new every-

thing—and they were written in the most un-understandable language that you can conceive of. Words adapted from all the dead languages and most of the living. I was about to write to Professor Trelease that I could not comply with his invitation because of the difficulty I had in understanding that literature. But presently I found in the old attic a page in an old arithmetic which had been stored there just forty years ago, and it looked just as bright and fresh as though it had been put there yesterday. It was the first page of Robinson's old Arithmetic, and it was divided up, as arithmetics were in those days, into questions and answers. The first question was, What is arithmetic? Answer, Arithmetic is the science of numbers. Second question, What is science? Answer, Science is knowledge systematically arranged. Thus I was relieved. I said, "There is something on the level of my own intelligence, and I will go." And so I am glad to welcome to St. Louis this Association of earnest men and women who are devoting their lives to the advancement of knowledge systematically arranged, and whether it be the knowledge of the physical earth, or knowledge of laws which control the physical earth, or whether it be the knowledge of those other laws and forces which control the inhabitants of the earth, I welcome you most cordially to St. Louis. And I will express the hope that you may continue to progress in your work until all the knowledge of the world shall be so systematically arranged that no man shall be able to excuse his errors on the ground of ignorance.

President WRIGHT: The President of the Board of Education, Prof. C. M. Woodward, is with us this morning, and as a representative of the educational institutions of St. Louis and Missouri, I have the honor of presenting him.

Professor WOODWARD: Mr. President, and Members of the Association: I am here to-day in three capacities. I am a citizen of St. Louis, and therefore am very glad to join in this welcome. I am a member of the faculty of Washington University, and although I am in no way authorized to speak for that university I take the risk of welcoming you in its behalf. You will see something of its future home when you go out to see the exposition, and you will join with us, I am sure, in the pleasure that we all feel in the building of a new and fine university.

But I am especially here in the interest of our public schools, and as president of the Board of Education and in the interest and in behalf of that Board, I welcome you to the city, to this building and all its conveniences. We trust you will find the rooms and apartments suitable for the meetings of the Association. We desire in every way to make you comfortable and to make things convenient. Moreover, I believe that education comes properly within the consideration of this Association. School administra-

tion, school management, is amenable to the laws of science, and we have done something in the way of school administration which we wish you knew about, but which I will not detain you this morning to tell about. On behalf of all the interests of education in this great city and throughout the State with which I have been associated for a generation, I welcome you to these quarters, to this city, and to the State.

President WRIGHT: Governor Francis, Mr. Walbridge, and Professor Woodward, it is a pleasure on behalf of the Association to thank you for your kindly and generous welcome, and to assure you that we accept it in the spirit in which it is given.

I think that the members of the American Association will take great pleasure and much interest in seeing the progress that has been made in preparing for the exposition next year. We cannot fail to recognize the important historical event which that exposition celebrates, and to feel, as we visit this part of the United States that that great transaction one hundred years ago made the future welfare and greatness of the United States, notwithstanding that the great negotiator of that purchase did not hesitate to say at the time that it would take at least one thousand years to settle the Northwest. And here one hundred years are bringing this body of scientists into one portion of the Northwest where we find great cities and all the advancement which has come to any part of the country. So as scientists we realize that the exposition—that its great utility, will not be recognized for some time to come. No matter what the physical developments of an exposition may be, they are sometimes questionable so far as utility is concerned, but the other side of it, the soul of the exposition, will live. Herein lies the great value of such enterprises, the bringing together of men from all parts of the world so that they can become acquainted with each other, each learning what the other is doing, each understanding the progress that has been made in scientific directions, in the matters of art, and in the great departments of education. Herein, I say, lies the chief value of such an enterprise as the exposition to celebrate the purchase of the Louisiana Territory.

I was greatly pleased with what Mr. Walbridge said about the language of science. Let me assure him that while the representative of each department of science here this morning has a terminology of his own which the other branches cannot understand, yet when we get down to solid business we all speak plain English. I remember a little symposium in Washington two or three years ago, at the house of a good friend now deceased (and I see before me some of the gentlemen who were present at that time), and they were speaking of a little simple problem easily demonstrated, known as the fourth dimension. It is such a practical one in life, it helps us so much to understand it, that the

question was discussed with great enthusiasm. and after the mathematicians, physicists, philosophers, etc., each talking in his own terminology, were through with the discussion, one gentleman, well known through the breadth of the land and throughout the world, said to one of the others, "Doctor, I have listened with great interest to what you have been saying, but I have not understood one single word." Nevertheless, when the host took us down to lunch, we found plain English sufficient to express all our wants.

It is a pleasure to be welcomed here on behalf of the educational institutions of the city and of the State, and I am sure that we shall find here the most advanced work in educational matters that can be found in the United States. St. Louis has long held a very high place in such matters, and it is interesting to know that some years ago St. Louis sent east for two of our principal educators, Dr. Harris and Professor Woodward. They did their work here and did it successfully, and then the east reciprocated the draft which had been made upon it by St. Louis, taking two of her best educators, Dr. Pritchett and Dr. Engler, and planting them at the head of great educational institutions in the Commonwealth of Massachusetts. So we are even, and there has been no loss. If St. Louis keeps up its pace in educational matters as it was set by these two men, I am sure that the members of the American Association will realize it and go away from this goodly city with commendations and praises for all that has been done here.

Gentlemen, we thank you for your kindly welcome.

Mr. Howe (acting General Secretary in place of Mr. Stiles): The Council has voted to extend the privileges of associate membership for this meeting to members of the local committee, residents of St. Louis and vicinity, and to members of the affiliated societies.

The Local Secretary, Mr. Langsdorf, made announcements in regard to registration of members of affiliated societies. and about the arrangements for lunch.

President Wright announced that each day the Council would meet at 9 in the morning and the general session at 10 o'clock.

After the adjournment of the general session the several sections were organized in their respective rooms.

On Monday afternoon the vice-presidents' addresses were given as follows:

At 2:30 P. M.

Vice-President Halsted before the Section of Mathematics and Astronomy, entitled "The Message of Non-Euclidean Geometry."

Vice-President Baskerville before the Section of Chemistry, entitled "The Elements: Verified and Unverified."

Vice-President Davis before the Section of Geology, entitled "Geography in the United States."

At 4:00 P. M.

Vice-President Waldo before the Section of Mechanical Science and Engineering, entitled "The Relation of Mathematics to Engineering."

Vice-President Hargitt before the Section of Zoology, entitled "Some Unsolved Problems of Organic Adaptation."

Vice-President Newcomb before the Section of Social and Economic Science, entitled "Some Recent Phases of the Labor Problem."

On Monday evening the address of the retiring president, Dr. Ira Remsen, entitled "Scientific Investigation and Progress," was given in the Odeon.

On Tuesday evening President David Starr Jordan, of Stanford University, gave a public lecture on "The Resources of Our Seas." After the lecture the American Society of Naturalists and affiliated societies held their annual smoker at the University Club.

On Wednesday afternoon the American Society of Naturalists held their annual public discussion, the subject being "What Academic Degrees should be conferred for Scientific Work?"

On Wednesday afternoon Professor E. Rutherford, of McGill University, Montreal, Canada, gave an illustrated public lecture on the subject "Radium and Radio-activity."

On Wednesday evening the retiring president of the American Chemical Society, Dr. John H. Long, delivered an address upon the subject "Some Problems in Fermentation."

On Wednesday evening the American Society of Naturalists held its annual dinner at the Mercantile Club, after which was given the address of the retiring president, Professor William Trelease.

On Wednesday evening the annual dinner of the American Chemical Society and Section C was given at Faust's.

On Wednesday evening Dr. S. F. Emmons gave the president's address before the Geological Society of America at the Planters' Hotel.

On Thursday afternoon, by invitation of the officers of the Louisiana Purchase Exposition, the members of the Association and affiliated societies visited the exposition grounds. A buffet luncheon was tendered the Association by the officers of the exposition, after which they were taken in small parties through the grounds and buildings and shown the various exhibits, under the personal charge of the chiefs of departments.

On Thursday evening the annual banquet of the Sigma Xi Honorary Scientific Society was given at the Mercantile Club, followed by the address of President David Starr Jordan.

On Friday evening the members of the Association attended the fourteenth annual banquet given by the trustees of the Missouri Botanical Garden at the Southern Hotel.

REPORTS OF COMMITTEES.

The following reports of committees were presented to the Council. They were accepted and ordered printed.

On the Atomic Weight of Thorium.

To the Council of the American Association for the Advancement of Science.

Gentlemen: Since our last report we beg leave to state that Messrs. Charles Baskerville and R. O. E. Davis have secured further evidence of the complexity of the so-called element, thorium. This work has resulted from applications of methods of fractionation to the large amounts of purified material with which they were engaged, as stated in our last report. Under such circumstances these gentlemen deemed it advisable to prosecute further the fractionation until a stable thorium preparation was secured. This fractionation is controlled by atomic weight determinations and spectroscopic examinations.

At the Washington meeting of the Council a grant of fifty dollars was made Mr. Charles Baskerville for work on præseodidymium, and the supervision of the same given over to this committee. Concerning this, we beg leave to state that Messrs. Baskerville, James Thorpe, and T. B. Foust have secured about one kilogram of quite pure oxide by novel methods. At present Messrs. Baskerville and G. MacNider are subjecting a considerable portion of this purified material to a treatment which promises to show the complexity of this so-called element.

We therefore beg leave to report progress.

Respectfully,

Chas. Baskerville, *Chairman.*
Francis P. Venable.
Jas. Lewis Howe.

On the Relation of Plants to Climate.

To the Council, A. A. A. S.

Gentlemen: The committee on the relation of plants to climate presents herewith a paper entitled "Soil Temperatures and Vegetation," which sets forth recent results obtained by the aid of grants received in 1901 and 1902, and which was published in Contributions from the New York Botanical Garden (No. 44).

Your committee is desirous of extending the observations already made to cover a wider range of soil and climatic conditions,

and has secured the co-operation of the New York Botanical Garden and of the Desert Botanical Laboratory of the Carnegie Institution, both of which have undertaken the purchase and installation of sets of instruments. The major inquiry is concerned with the influence of the temperature of soils, with its diurnal and seasonal variations, upon growth and distribution of plants. As a result of the observations already made it has been found that different portions of the body of even small plants may differ as much as 40° F. in temperature, a fact which has hitherto escaped notice and which promises to be of great importance in the interpretation of the physical processes of the plants. In order to carry along the entailed investigations, your committee asks an additional grant of seventy-five dollars.

During the course of the work the Hallock soil thermograph has been invented and perfected. Specifications have been placed in the hands of a competent instrument maker, and no limitations of any kind placed on its manufacture or use. The numbers of applications for instruments show that it is deemed useful for thermometric work in various kinds of observations.

Respectfully.

D. T. MacDougal,
For the Committee.

William Trelease,
J. M. Coulter,
D. T. MacDougal.
Committee.

On Anthropometric Tests.

The committee of the Association on anthropometric tests has continued its work throughout the year. A laboratory for physical and mental measurements was arranged at Washington and tests of the fellows and members of the Association were made by Mr. Miner and Mr. Davis under the direction of the chairman of the committee. The results of measurements of about one hundred fellows have been compiled and compared with similar measurements of members of the British Association and of other classes of the community, but the data are not yet sufficiently numerous for publication. Dr. McGee, of the committee, has taken steps toward the establishment of anthropometric and psychometric laboratories as part of the Louisiana Purchase Exposition, with special reference to the measurement of the savage tribes that will be gathered there. Professor Boas, of the committee, has published measurements of the cephalic index in relation to Mendel's law, and has carried forward anthropometric work in other directions. The chairman of the committee has published two papers

on the natural history of American men of science, seeking to apply metric methods to merit and other individual differences. Numerous measurements of physical and mental traits have been made in the psychological laboratory of Columbia University and work has been carried on in the schools of New York City on the resemblance of brothers and twins, and in other directions. Professor Thorndike has published a book on Educational Psychology, concerned especially with the application of anthropometric methods to children.

It did not appear feasible to arrange an anthropometric laboratory at St. Louis. We ask that the fifty dollars appropriated for such a laboratory be made available for next year.

J. McKeen Cattell,
Chairman.

On Indexing Chemical Literature.

The committee on indexing chemical literature, appointed by your body at the Montreal meeting in 1882, respectfully presents to the Chemical Section its twenty-first annual report, covering the twelve months ending June 1, 1903.

WORKS PUBLISHED.

An Index to the Literature of Thorium (1817–1902). By Cavalier H. Jouet, Ph. D. Smithsonian Miscellaneous Collections, No. 1374. Washington City, 1903.

References to Capillarity to the end of the year 1900. By John Uri Lloyd (aided by Sigmund Waldbott). Bulletin No. 4 of the Lloyd Library of Botany, Pharmacy and Materia Medica. Cincinnati, Ohio, 1902. 212 pp., 8vo.

The 665 "references" extend from 1519 to 1900; each is accompanied by a summary of the contents of the paper cited.

The Journal of the American Chemical Society. General Index to the first twenty volumes, 1879–1898, and to the proceedings, 1877–1879. Easton, Pa., 1902. 237 pp., 8vo.

Though issued anonymously, the preface bears the initials of E. W. Morley and O. F. Tower, and the labor was one of love. Accuracy of detail and adequate treatment on every page are its admirable features. Besides an index of authors and an index of subjects, there is an index of obituaries which is suggestive. Also an index of new books.

NOTES ON FOREIGN BIBLIOGRAPHIES.

A Bibliography of Steel-works Analysis, by Harry Brearly, forms an appendix to the volume entitled "The Analysis of Steel-

works Materials," by HARRY BREARLY and FRED IBBOTSON. London, 1902.

This bibliography comprises 1858 references, which occupy more than 130 pages 8vo. The items are grouped under seven heads, besides minor subdivisions; the literature is, however, very incomplete, being confined to four British journals.

A Catalogue of the Library of the Chemical Society (*of London.*) Arrangėd according to authors with a subject index. London, 1903. 8vo. 324 pp.

International Catalogue of Scientific Literature. First Annual Issue (for the year 1901). D. Chemistry. Published for the International Council by the Royal Society of London. London, 1902. Vol. II, Part I. June, 1902.

WORK IN PROGRESS.

A second supplement to the Select Bibliography of Chemistry, by Dr. H. Carrington Bolton, has been completed and accepted for publication by the Smithsonian Institution. It brings the literature down to the end of the year 1902.

An index to the literature of cadmium has been begun by Prof. Ernest N. Pattee, of Syracuse University.

An index to the literature of glucinum has been begun by Prof. Charles L. Parsons, of New Hampshire College, Durham, New Hampshire.

An index to the literature of germanium, gallium, and indium has been begun by Dr. Philip E. Browning, of New Haven, Conn.

Mr. Frank R. Fraprie, writing from Munich, Bavaria, reports substantial progress on an index to the literature of lithium, Cæsium and rubidium.

Mr. Benton Dales is engaged on an index to the literature of the yttrium group of the rare earths. His address is Ithaca, New York.

H. CARRINGTON BOLTON (in Europe),
F. W. CLARKE (in Europe),
ALBERT B. PRESCOTT,
ALFRED TUCKERMAN,
H. W. WILEY,

JUNE 1, 1903. *Committee.*

ON THE VELOCITY OF LIGHT.

The committee reports progress since the Pittsburg meeting in the preliminary study of the methods of determining the group velocity and the absolute velocity of light in ponderable media and in space.

The practicability of the method, involving the use of electric double refraction and electric oscillations for producing groups of waves, and the examination of them through a column of water at least 100 feet long and probably twice that distance, has been established.

An estimate from the corresponding optical conditions in air would make the available distance several miles. The preliminary study of the method for determining the absolute velocity has not yet been completed, but the apparatus is partly mounted and in place.

The committee petitions a further grant of seventy-five dollars for the continuance of the preliminary experiments now in progress.

Respectfully submitted.

D. B. Brace,
For the Committee.

On the Teaching of Anthropology in America.

To the President and Council:

Your committee on the teaching of anthropology in America beg to report progress.

During the year 1902 (for which a brief report was submitted to the Council, though apparently lost before reaching the Secretary of the Council), the committee held one or two conferences, while different members took individual action in accordance with the general policy looking toward the promotion of anthropologic education in several leading institutions. Dr. MacCurdy, of the committee, continued the collection and publication of statistics as to the teaching of anthropology; and Dr. Boas, Dr. Russell, and the chairman of the committee delivered addresses and published papers advocating the extension and betterment of anthropologic teaching in this country. During the year 1903 the committee have continued work, chiefly as individuals, and different members have been consulted and have expressed opinions as to the value of anthropology as a subject of instruction in educational institutions. Recently, the committee has suffered a grievous loss in the death of Dr. Frank Russell, one of the original members of the committee.

It is recommended that the committee be continued, and that the vacancy created by the death of Dr. Russell be filled by the appointment of Dr. Roland B. Dixon, of Harvard University. Since the work of the committee is performed in occasional conferences and by correspondence, entailing little expense, no grant is asked for its maintenance.

Respectfully,

W J McGee, *Chairman.*
George Grant MacCurdy.

On Grants.

The committee on grants made the following report and recommendations, which were adopted:

The committee on grants recommends that appropriations for the ensuing year be made as follows, namely:

To the Concilium Bibliographicum of Zurich, $100.

To the Committee on the Atomic Weight of Thorium, $100.

To the Committee on the Study of the Relations of Plants to Climate, $75.

To the Committee on Determination of the Velocity of Light, $75.

To a Committee of Section C, to be appointed, to study certain problems in electrochemistry, $60.

To give effect to this last recommendation, the following resolution is suggested:

Resolved, That a committee consisting of Professors W. D. Bancroft, Edgar F. Smith, and L. Kahlenberg, be appointed to conduct said investigations in electrochemistry, and that this committee be designated the Committee on Electrochemistry.

On Policy of the Association.

The Committee on Policy of the Association reported the following resolutions, which were adopted:

(1) Concerning the proposition to authorize the appointment of an executive committee of five to consult with the Permanent Secretary and arrange details of the meetings; that the functions of such proposed executive committee be performed by the Committee on the Policy of the Association.

(2) The Committee on the Policy of the Association recommend to the Council that at the next annual meeting only three general sessions be held, namely, those of Monday, Wednesday, and Friday of the week of meeting.

(3) Amend Article 34 by the omission of the words "on the election of any member as a fellow an additional fee of two dollars shall be paid."

(4) That the commutation of secretaries of sections be fixed at $30 for each meeting of the Association, provided that these secretaries lodge during the whole meeting at the hotel headquarters of the Association.

In regard to granting credentials to members of the Association who wish to visit foreign associations, the committee recommended that all such applications be referred to the Committee on Policy, with power.

In regard to the application of the Society of College Teachers of Education, and of the Society for Horticultural Science for affiliation with this Association, the Committee recommended that the applications be granted.

On the Relations of the Journal Science with the Association.

On the recommendation of this committee it was voted:

(1) That the Treasurer be added to this committee.

(2) That the Vice-Presidents of the Association and the Permanent Secretary be added to the editorial committee of the journal *Science*.

On Amendments.

The following amendments to the Constitution having been proposed at the Washington meeting, favorably acted upon by the Council, and reported to the general session, were adopted:

Article 34, second line, change the word *assessment* to the word *dues*.

Article 35, first line, change the word *assessment* to the word *dues*.

Article 37, first line, change the word *assessment* to the word *dues*.

On Resolutions.

The following resolutions were proposed and adopted at the meeting of the general session held Friday, January 1:

In view of the extremely complete and effective arrangements which have guarded and guided the conduct of the multiplied activities of the meeting with such unusual success, and in the thought of the many courtesies which have been extended to us on every hand with most genuine hospitality, it is a peculiar pleasure to be called upon to present for adoption by the Association the resolution of thanks which are so incomplete an expression of our appreciation of these privileges. At the same time, each one of us must feel that the most extended enumeration would only partially include the many who have so generously contributed to make this meeting a success in every direction.

First of all, the thanks of the Association must be extended to the local committee, and particularly to the honorary president, the Hon. David R. Francis; to the chairman, Prof. William Trelease; to the secretary, Prof. A. S. Langsdorf; to the treasurer, Mr. William H. Thomson; and to the members of the executive committee, Chancellor W. S. Chaplin, Mr. George H. Morgan, Prof. F. E. Nipher, Mr. John Schroers, Mr. Walter B. Stevens, Dr. Wil-

liam Taussig, and Mr. H. C. Townsend, who, as chairmen of the various sub-committees, have arranged for all the details with such forethought as to keep the machinery of a large and complicated program in operation without friction or interference, and to provide for many outside courtesies of the most enjoyable type.

Sincere thanks are due to the Board of Education for placing at our disposal the Central High School building, so admirably adapted to the purposes of this meeting; to Superintendent of Public Instruction F. S. Soldan; to Principal W. J. S. Bryan and his corps of assistants and students for their untiring efforts in caring for the various sections, and to Messrs. George F. Knox, William Butler, and S. A. Douglas for their continued care and manipulation of the lanterns and other appliances placed at the disposal of the sections.

The Association is deeply indebted to the trustees and director of the Missouri Botanical Gardens for hospitalities extended to members in connection with their visits to this splendid institution, and for the exceptional courtesies tendered in connection with the Shaw banquet.

The Association is under obligations to the officers of the Louisiana Purchase Exposition for the luncheon and reception at the grounds of the Exposition, and to the chiefs of departments under whose guidance the members were privileged to witness the progress already made toward the completion of this monumental work.

The Association must further acknowledge its indebtedness to the press, to the St. Louis Transit Company, to the president of the Board of Public Improvements, and to all other organizations, corporations, and individuals who have extended so many privileges to members individually and in groups in connection with visiting the great industries and points of interest in St. Louis and vicinity.

The Association is under deep obligation to the Mercantile Club, to the University Club, and finally, and in especial measure, to the Wednesday Club, for the thoughtful hospitalities extended to the ladies registered at the meeting.

It was unanimously voted to extend the thanks of the Association to Professor Rutherford for his lecture on Radium and Radioactivity.

General Committee.

At the meeting of the General Committee, held Thursday evening, it was decided to hold the next meeting in Philadelphia, beginning Tuesday, December 27, 1904, and closing Monday, January 2, 1905, it being understood that the Executive Committee of the

Council will meet Tuesday, December 27, and the opening session of the meeting will be held Wednesday, December 28. New Orleans was recommended as the place of meeting two years hence.

The following officers were elected for the Philadelphia meeting:

President—W. G. Farlow, Cambridge, Massachusetts.

Vice-Presidents:

Section A—Alexander Ziwet, Ann Arbor, Michigan.

Section B—William F. Magie, Princeton, New Jersey.

Section C—Leonard P. Kinnicutt, Worcester, Massachusetts.

Section D—David S. Jacobus, Hoboken, New Jersey.

Section E—Eugene A. Smith, University, Alabama.

Section F—C. Hart Merriam, Washington, D. C.

Section G—B. L. Robinson, Cambridge, Massachusetts.

Section H—Walter Hough, Washington, D. C.

Section I—Martin A. Knapp, Washington, D. C.

Section K—H. P. Bowditch, Cambridge, Massachusetts.

General Secretary—Charles S. Howe, Cleveland, Ohio.

Secretary of the Council—Clarence A. Waldo. Lafayette, Indiana.

Secretaries of the Sections:

Section A—L. G. Weld, University of Iowa, Iowa City, Iowa.

Section B—Dayton C. Miller, Case School, Cleveland, Ohio.

Section C—C. L. Parsons, New Hampshire College, Durham, N. H.

Section D—Wm. T. Magruder, Ohio State University, Columbus, Ohio.

Section E—E. O. Hovey, American Museum of Natural History, New York, N. Y.

Section F—C. Judson Herrick, Denison University, Granville, O.

Section G—F. E. Lloyd, Teachers' College, Columbia University, New York, N. Y.

Section H—Geo. H. Pepper, American Museum of Natural History, New York, N. Y.

Section I—J. F. Crowell, Bureau of Statistics, Washington, D. C.

Section K—(No election).

Treasurer—R. S. Woodward, Columbia University, New York, N. Y.

CHARLES S. HOWE,
General Secretary.

REPORT OF THE TREASURER.

[The Treasurer's report will not be printed in this volume owing to the absence of the Auditor in Europe.]

Report of the Permanent Secretary.

The matters heretofore referred to in the report of the Permanent Secretary, in so far as they relate to the annual meeting, have been covered in the report of the executive proceedings prepared by the General Secretary, and duplication is avoided by omitting them under the present head.

The following is a comparative statement of the roll of members as printed in the Pittsburg and Washington volumes and in the present volume:

	Pittsburg.	*Washington.*	*St. Louis.*
Surviving founders	3	3	3
Living patrons	2	2	2
Living honorary fellows	3	3	3
Fellows	1,074	1,197	1,255
Members	2,392	2,787	2,864
Totals	3,474	3,992	4,127
Honorary life fellows (founders) included in the above	3	3	3

L. O. Howard,
Permanent Secretary.

L. O. HOWARD, PERMANENT SECRETARY, IN TION FOR THE ADVANCE-

From January 1. 1903, *to*

DR.

To balance from last account		$15,756.81
Admission fees	$2,096.00	
Annual dues for 1903	2,964.00	
Annual dues for 1904	6,754.00	
Annual dues for previous years	164.00	
Associate fees	183.00	
Fellowship fees	196.00	
Life membership fees	270.00	
		12,627.00
Publications	96.26	
Subscription for volume	1.50	
Binding	74.80	
Miscellaneous receipts	180.85	
Interest	91.53	
		444.94
		$28,828.75

ACCOUNT WITH THE AMERICAN ASSOCIA-MENT OF SCIENCE.

December 31, 1904.

CR.

By publications.		
To publishers SCIENCE	$7,276.50	
Volume 51	1,579.95	
Volume 52	1,622.00	
Washington pamphlet and part program	728.83	
		$11,207.28
By expenses Washington meeting.		
Sectional secretaries and additional help	418.32	
By part expenses St. Louis meeting.		
Sectional secretaries and miscellaneous expenses	241.05	
		659.37
By general office expenses, including propagandist work.		
Postage	841.43	
Express	394.86	
Printing circulars, etc	245.11	
Extra clerical help	102.65	
		1,584.05
By salaries.		
Permanent secretary	1,500.00	
Assistant secretary	750.00	
Assistant secretary	250.00	
		2,500.00
By miscellaneous disbursements.		
Overpaid dues returned	24.00	
Purchase of back volumes	33.00	
Other miscellaneous small disbursements	84.90	
		141.90
By balance to new account		12,736.15
		$28,828.75

I hereby certify that I have examined this account and that it is correctly cast and properly vouched for, and that the balance was on deposit in Washington as follows: Citizens' National Bank (January 11, 1904) $1.05; National Safe Deposit and Trust Company (January 1, 1904), $1,563.07; American Security and Trust Company (January 2, 1904), $3,501.76; and American National Bank (January 9, 1904), $7,670.27; in all $12,736.15.

G. K. GILBERT, *Auditor.*

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